AERONAUTICAL ENGINEERING REVIEW

AUGUST 1949

Second International

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SPERRY

Conference Issue

Latest versions of the U. S. Navy's Lockheed P2V Search-Patrol Plane are cooled by Clifford Feather-Weight All-Aluminum Oil Coolers. The P2V's are the first search-patrol planes ever designed "from the ground up" for the Navy. One of this series, the "Truculent Turtle" holds the world's non-stop distance record of 11,236 statute miles for a flight from Perth, Australia to Columbus, Ohio in the fall of 1946. Production of the P2V's is under way at Lockheed Aircraft Corporation Factory at Burbank, California.
Oil Cooled by Feather-Weights

The Lockheed P2V joins a distinguished group of modern conventional and jet-propelled aircraft now benefiting from the superior weight-strength ratio and accurate pre-testing of FEATHER-WEIGHT all-aluminum oil coolers.

Clifford's patented method of brazing aluminum in thin sections and the thorough testing methods used in Clifford's wind-tunnel laboratory . . . largest and most modern in the aeronautical heat exchanger industry . . . contribute to increasing popularity of Feather-Weights.

Inquiries concerning Feather-Weight All-Aluminum Oil Coolers are invited. CLIFFORD MANUFACTURING COMPANY, 138 GROVE ST., WALTHAM 54, MASS. *Division of Standard-Thomson Corporation.* Offices in New York, Detroit, Chicago and Los Angeles.

CLIFFORD

HYDRON

ALL-ALUMINUM OIL COOLERS
FOR AIRCRAFT ENGINES

HYDRAULICALLY-FORMED BELLOWS
AND BELLOWS ASSEMBLIES

H. R. Salmon,
winner of 1948 race.

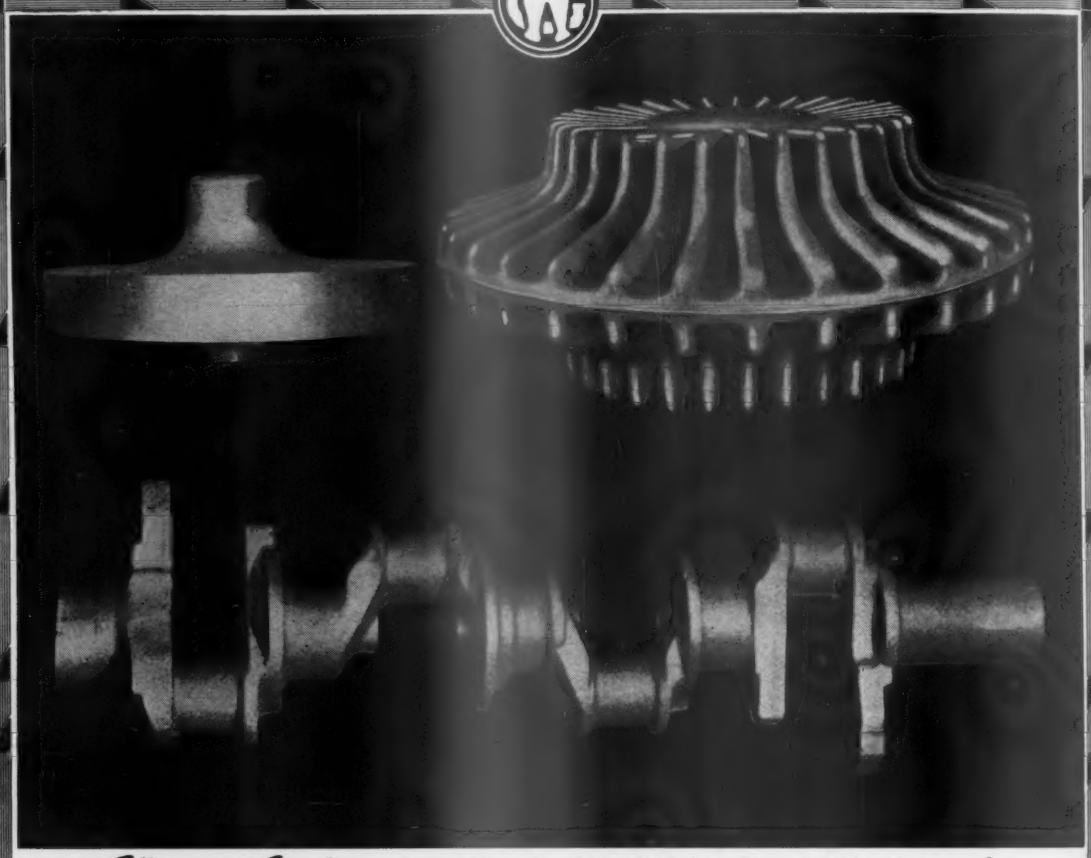
WELCOME
America's
CLASSIC OF THE AIR

The Goodyear Trophy Race – Sept. 3, 4, 5

For the third consecutive year, The Goodyear Tire & Rubber Company will sponsor the $25,000 Goodyear Trophy Race for light aircraft at the National Air Races, Cleveland, Ohio. This popular contest is creating wider public interest in small airplanes and stimulating progress in their design and engineering through competitive effort. It is another Goodyear contribution to the advancement of aviation. Goodyear, Aviation Products Division, Akron 16, Ohio or Los Angeles 54, California.

GOODYEAR
AVIATION
PRODUCTS

MORE AIRCRAFT LAND ON GOODYEAR TIRES, TUBES, WHEELS AND BRAKES THAN ON ANY OTHER KIND



Wyman-Gordon—specialists in the vital forgings of the internal combustion engine since its inception—is today the largest producer of crankshafts for the automotive industry and of all types of forgings for the aircraft industry.

Be it crankshafts and other vital forgings for the piston type engines or turbine wheels and impellers for turbo jets—there is no substitute for Wyman-Gordon experience.

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WYMAN-GORDON

Forgings of Aluminum, Magnesium, Steel

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AERONAUTICAL ENGINEERING REVIEW

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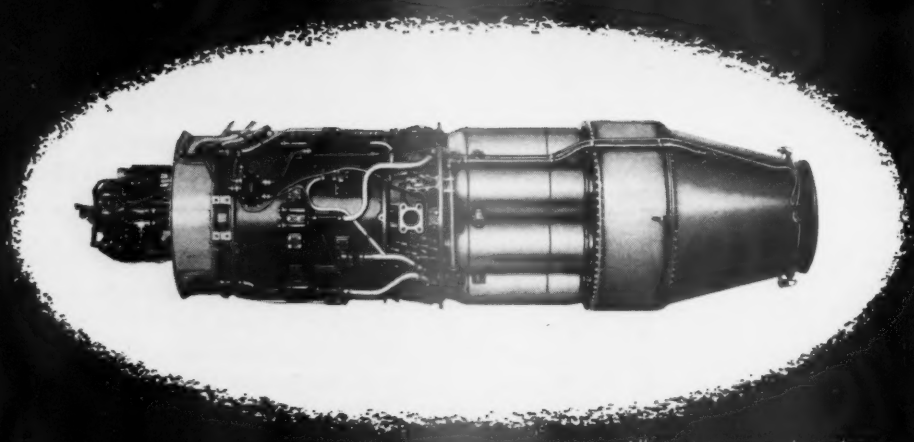
—✲3,200 TRIPS AROUND THE WORLD—

Allison aircraft turbine engines have logged
more than 200,000 hours' actual flight time to date—
more time in the air than all other jet engines.



J-35
Axial-flow
Turbo-jet

Allison jet-powered airplanes:
Lockheed F-80 and TF-80 Shooting Star
Republic F-84 Thunderjet
Grumman F9F-3 Panther
Northrop F-89A Scorpion
North American FJ-1 Fury
Consolidated XP5Y
Northrop RB-35B Flying Wing
Martin P4M-1 Mercator
North American AJ-1

Allison
DIVISION OF GM GENERAL MOTORS
Indianapolis, Indiana

Builder of axial and centrifugal flow turbine engines

I.A.S. News

A Record of People and Events of Interest to Institute Members

I.A.S. Holds Second Elmira Meeting with Soaring Society

Sweptback Wings, Cross-Country Soaring, and Meteorological Phenomena Discussed at Technical Sessions on July 8; Latest Sailplanes Exhibited on Harris Hill

ADVANCES IN THE aerodynamics and design of sailplanes and in the meteorological and operational aspects of soaring were reported on Friday, July 8, to members of the Institute of the Aeronautical Sciences and the Soaring Society of America at the second of a series of joint meetings at Elmira, N.Y. The first in this postwar series of meetings was held in July, 1948, and featured a Symposium on "Ultimate Performance Possibilities for Sailplanes." This year's meeting formed part of the program of the S.S.A.'s Sixteenth Annual National Soaring Meet, which opened on July 2 and ran until July 10.

The program of this year's meeting included the presentation of seven formal technical papers by members of both societies and an inspection of the latest sailplane designs. The technical sessions were held in the afternoon and evening in the Administration Building at Harris Hill. The commercially manufactured and privately built sailplanes on hand for the soaring contests afforded an interesting display of actual examples of recent sailplane development.

The program of the technical sessions was as follows:

▸ **Afternoon Session—Aerodynamics.** The Chairman was Ben Shupack, who is with the Aerophysics Institute, Inc., and is a Director of the Soaring Society of America. Four papers were read:

"The Sailplane Project," by August Raspet, Engineering and Industrial Research Station of Mississippi State College.

"A New Profile for Sweptback Wings," by D. F. Farrar, Jr., Vanderbilt University.

"Report on the D-30 Sailplane," by Hans Zacher.

"Optimum Cross-Country Soaring Speeds," by Paul B. MacCready, Jr., California Institute of Technology.

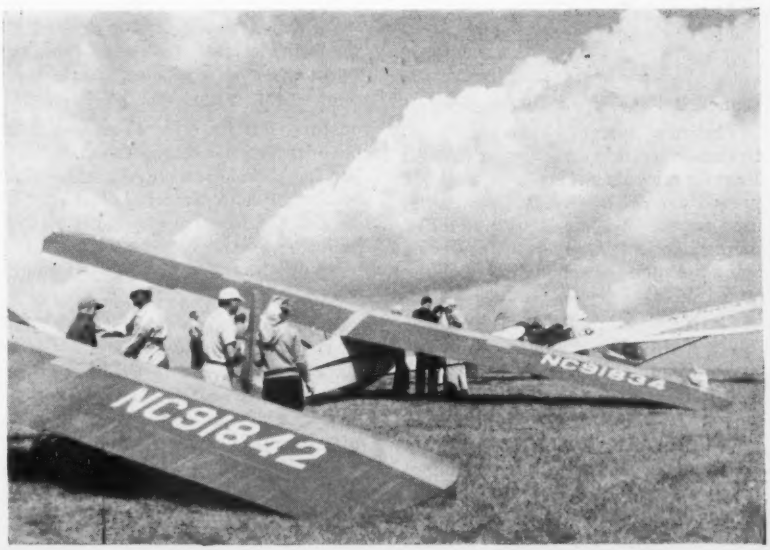
▸ **Evening Session—Meteorology.** Dr. August Raspet, Mississippi State College, was Chairman. Dr. Raspet is also an S.S.A. Director. The titles of the papers presented were:

"Prefrontal Waves and Their Significance to Soaring and Transport Aviation," by Walter Georgii, Meteorological Service of Argentina.

"Some Effects of Wind on Cumulus Clouds and Thermals," by Joanne Starr Malkus, Illinois Institute of Technology, Woods Hole Oceanographic Institute.

"The Techniques and Possibilities of Mountain Wave Soaring," by Joachim Kuettner, Air Materiel Command, U.S.A.F.

The October issue of the REVIEW will contain a complete account of the events of the meeting, including summaries of the technical papers and the discussions.



MARTIN STEPS UP MILLING PRODUCTION

Milling production stepped up 25 per cent in The Glenn L. Martin machine shop through improved operations, company reports. In one outstanding case, the bracket for a main beaching gear was originally loaded on the work table and milled—one unit at a time. Operator had to stop the machine while loading each successive part in the vise. Improved method, shown above, depends on the use of a rotary work table with nesting fixtures. Production has increased since the operator is himself constantly occupied in loading parts while machine keeps on chipping. Methods Engineer (center) looks on as Foreman checks beaching gear bracket turned out on improved setup. Parts are loaded on rotary table while machine runs.

Controlled Utilization Extends Clipper Flying Hours

Pan American World Airways' Clippers—the new Stratocruiser transports currently being delivered by Boeing—have their futures scheduled as much as 2 years hence, even before most of them have been delivered or completed.

▶ **Looking to Future**—This looking to the future policy is in line with a new long-range scheduling system developed by P.A.A. to provide for more economical maintenance of aircraft.

The new system, known as controlled utilization, was tested first on Pan American's fleet of DC-3's. It proved so efficient that it is now being used on the company's entire fleet of more than 100 Clippers. It also is being adapted for scheduling of flight crews.

The improved method of scheduling solves one of the major problems of aircraft maintenance—the separation of aircraft servicings and overhauls so that they do not bunch up and overload the maintenance department.

Reason for the pile-up of servicings and overhauls is that airplanes usually are purchased several at a time, which means that, without planned utilization, all normally would be due for servicing at about the same time, resulting in uneven work load for the maintenance division, with alternate slack and rush periods.

▶ **440 Hours Lost Per Plane**—Check by P.A.A in 1948 on 50 airplanes showed an average utilization of 1,560 hours per plane out of each 2,000-hour period, or a loss of 440 hours per plane. Extended through the 8,000-hour cycle each plane is allowed to fly before major overhaul, this represents a loss of 1,760 hours per plane.

Full utilization is difficult to achieve, but through the new system of controlled scheduling Pan American has succeeded in raising its utilization on the 260-hour servicing of its fleet of 40 DC-4's from an average of 220 hours to an average of 249 hours, increasing utilization 29 hours per plane.

Scheduling board graph, covering 6-month operating period, gives a constant and accurate picture of each plane's status and its location, so that it is apparent immediately whether the plane is behind or ahead of its projected maintenance schedule.

A plane out of phase with its overhaul schedule can be transferred to a run where its utilization can be advanced or retarded as necessary.

100,000 Key Engineers' Records Requested for Use by N.M.E.

To provide source material for a who's who in engineering research, development, and other scientific operations, a 4-page questionnaire has been mailed out to 100,000 key engineers in all branches of American engineering, it was announced by The American Society of Mechanical Engineers last month.

The Engineers Joint Council, acting through A.S.M.E., has accepted the task of providing the Office of Naval Research of the National Military Establishment with the names, addresses, ages and details of professional and scientific qualifications of engineers holding the grade of member or higher in 18 national professional engineering societies. The returns will be collected by the A.S.M.E. and turned over to the O.N.R. for classification.

▶ **Valuable Tool**—The source file of key engineering personnel thus obtained will provide a valuable tool for solving a variety of technical personnel problems, A.S.M.E. officials said. Its use will diminish disturbances of the national economy, organization of industry, and the personal welfare of engineers and will provide a means by which national resources of technical personnel can be ascertained. The file will also point up weak spots that should be strengthened by education, training, and other means, it was said.

As a national asset, the body of facts will be available to private industrial, educational, and professional-society planning groups and for other legitimate purposes.

▶ **Not Just Another Questionnaire**—The Engineers Joint Council points out that this is not just another questionnaire but is one sent to engineers selected from the upper echelon of the profession. Data sought are not intended for general Government use but will go directly to the engineering agencies of the N.M.E., who will make direct use of it.

As the questionnaire will provide the key to opportunity to professional and patriotic service, engineers selected to receive it are urged to give it serious attention and to answer all questions fully.

The project is the result of a conference held in Washington, D.C., last fall attended by E.J.C. representatives and many other engineering agencies, at which was discussed the need for a list of 25,000 key engineers who could be called in on a full- or part-time basis to work on the broad scientific programs of the National Military Establishment.

The task of collecting personal and professional data fell to the E.J.C. as

the largest joint agency of the engineering profession. A.S.M.E. assumed administration of the project as contracting agent of the E.J.C.

World's Largest 'Copter Maker Reaches Three-Ships-per-Week Mark

Stanley Hiller's United Helicopters, Inc., is now claimed to be the largest helicopter manufacturer in the world with a three-ships-per-week delivery rate. Hiller, an I.A.S. Technical Member, points out that the first commercial delivery was made only last February. Between that date and today, the corporation has stepped up production to its present figure to become the production leader of the industry.

▸ **4,000 Californians**—More than 4,000 Californians have sponsored the company's production engineering and manufacturing operations, making possible the rapid expansion to its present position. This immediate production goal has also been made possible by an unusual method of manufacturing, Hiller said, whereby approximately 92 per cent of the Hiller 360 is produced by subcontracting firms located mainly throughout the West. Some 125 persons are employed at United Helicopters' Palo Alto assembly plant, while about 400 are directly associated with the production program in the various vendors' plants.

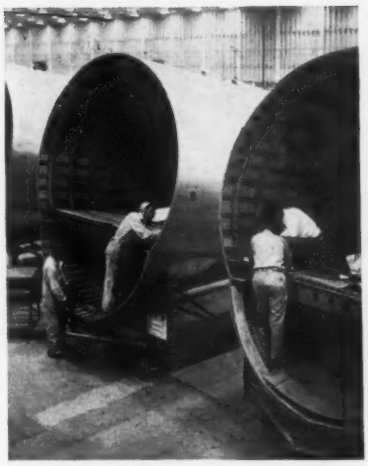
Helpful Helicopter

Paying a call at Andrews Air Force Base in the course of a tour of mid-Eastern Seaboard military bases, a K-190 helicopter designed by Charles H. Kaman, M.I.A.S., President, Kaman Aircraft Corporation, took aloft Major Gen. Lawrence S. Kuter, Chief, M.A.T.S.

The General, never one to make lost motions, took the opportunity to inspect three small lakes located on the base. The flight, it developed, had a practical purpose in that plans for improving the base include the possibility of draining and filling in one or two of the lakes.

▸ **Photo-Recon**—After hovering over each lake for several minutes, General Kuter decided a photographic record of the inspection would be helpful to the project. The K-190 landed him on the lawn within 50 ft. of his home quarters where he obtained a camera and resumed his flight to photograph the area.

The K-190, in more than 1,000 miles of cross-country flying plus an unknown number of miles in shorter flights, required only 3 hours of normal maintenance and no parts replacements in 109 hours of flight.



C-97 REAR SECTIONS BY RYAN

Fabrication work on the aft fuselage sections of Boeing's C-97 Stratofreighters for the Air Force is progressing rapidly along Ryan Aeronautical Company's production lines. Ryan also builds fuselages for the Boeing Stratocruiser. By year-end, Ryan-built C-97 sections will reach top delivery rate.

I.A.S. Newslines

▸ Elected Lear, Inc., V.-P. . . . **Burnham Adams,** A.F.I.A.S., Manager of the California division of Lear, Inc., since May, 1946, was elected Vice-President of the corporation. Before joining Lear, he was at Wright Aeronautical for 22 years, having been Sales Manager and later West Coast Manager. Mr. Adams is a graduate of Yale Engineering School.

▸ Reaches Mach 7.06 . . . A hypersonic wind tunnel has been unveiled at the University of Minnesota which created a proved airflow seven times the speed of sound. According to **Prof. John D. Akerman,** F.I.A.S., Head of the Aeronautical Engineering Department, tests conducted with hypodermic needles disclosed the air stream to have reached Mach 7.06 in the 6 by 9-in. test section.

▸ McGraw-Hill Director . . . **Dr. Karl T. Compton,** F.I.A.S. and Chairman, Research & Development Board of the National Military Establishment, has been elected a Director of the McGraw-Hill Publishing Company, New York.

▸ Honored . . . At Commencement Exercises of Polytechnic Institute of Brooklyn last June 15, **Dr. Hugh L. Dryden,** H.F.I.A.S., received the honorary degree of Doctor of Science in recognition of his distinguished achievements in aeronautical engineering.

▸ New Tau Omega Prexy . . . At an annual convention of Tau Omega, national honorary aeronautical engineering fraternity, held on the campus of Illinois Institute of Technology, **Dr. Harold V. Hawkins,** A.F.I.A.S., was elected National President.

▸ On Rensselaer Faculty . . . **Dr. Paul E. Hemke,** A.F.I.A.S., has been appointed dean of faculty at Rensselaer Polytechnic Institute, Troy, N.Y. He served as head of the Department of Aeronautical Engineering there since 1936.

▸ For Distinguished Service . . . **Glenn L. Martin,** H.F.I.A.S., received an honorary degree of Doctor of Science from the University of Southern California "in recognition of distinguished service in the field of aeronautics."

▸ Guided Missiles Chairman . . . **Dr. Clark B. Millikan,** H.F.I.A.S., has been named Chairman of the Committee on Guided Missiles, Research & Development Board, replacing Dr. F. L. Hovde, Purdue University President.

▸ Negotiating Transport Lease . . . **W. C. Rockefeller,** A.F.I.A.S., Vice-President of Airfleets, Inc., believes air-line companies of this country will soon arrange to lease new transports through the company. "Our studies," he said, "show that several air lines can shift within a short time to profitable operations through the leasing plan." Convair-Liners will be first transports leased by Airfleets, which is now negotiating with domestic air lines. A firm proposal is expected to be submitted to the RFC soon to finance the plan.

National Meetings Calendar

Dec. 17	Wright Brothers Lecture, Washington, D.C.
Jan. 23–26, 1950	Eighteenth Annual Meeting, New York.

CARRYING ITS OWN AIRPORT

Largest installation of its type ever built, the massive track-tread landing gear on the Boeing B-50 Superfortress received its first taxi trials at Seattle. The track gear is being used to test the practicality of flying heavy airplanes from unimproved airfields. Rubber belts, grooved drums, and bogies, with multiple shock absorber units, allow the 164,000-lb. B-50 to roll over small obstructions and turf or dirt with ease, Boeing says. All three landing-gear units completely retract and do not affect the 400-m.p.h. top speed of the Air Force's standard medium bomber, company added. Tripod pedestal attached to plane's nose holds motion-picture camera equipment to record automatically the action of nose gear during high-speed taxi tests.

Corporate Members News

• "Inside Story" . . . New 8-page bulletin, "The Inside Story of Allis-Chalmers 'Safety Circle' Motor Protection," has been released by the company. Design and construction features of the "Safety Circle" motor which add up to long life and low operating costs are described. These include a heavy cast-iron frame completely surrounding all working parts, a double insulated stator, a die-cast rotor, efficient ventilation, drip-proof end brackets, prelubricated bearings, precision machined feet, and roomy conduit box. These motors are available in sizes from 1 hp. at 1,800 r.p.m. to 20 hp. at 3,600 r.p.m., in frames 326 and smaller. All dimensions are NEMA standards. Copies of *Bulletin 51B6210B* are available on request from **Allis-Chalmers Manufacturing Company,** 1227 S. 70th St., Milwaukee, Wis.

• Supports U.S.-Canada Pact . . . New transport agreement between Canada and U.S. will improve this country's unfavorable competitive position on the air route linking New York with Toronto, according to C. R. Smith, A.M.I.A.S., President of **American Airlines System.** Saying American has been operating between the two cities for 8 years, during which it suffered a severe competitive disadvantage because T.C.A. has been able to offer faster service because of its nonstop privilege while American was required to stop all New York-Toronto flights at Buffalo, Smith declared initial nonstop service by American is planned on basis of two daily flights with Convair-Liner Flagships, cutting time from 2 hr. 40 min. to 1 hr. 45 min.

• Renton Stratofreighters . . . First of 50 Boeing Stratofreighters for the Air Force which rolled from the Renton Aircraft Plant near Seattle last June was also first plane to be completed in the big Government-owned factory since last B-29 was completed 3 years ago by **Boeing Airplane Company.** Production will continue into 1950.

• Cal-Aero Accreditation . . . **Cal-Aero Technical Institute** has announced the accreditation of its curriculum in Aeronautical Engineering by the Engineers' Council for Professional Development.

• Best Safety Record . . . The best safety record ever established by air lines flying a new type transport in its first year of operation was set when Convair-Liners began their second year of scheduled service, according to **Consolidated Vultee Aircraft Corporation.** Domestic and foreign lines flying more than 150 of the twin-engined transports, logged about 500,000,000 passenger-miles and 25,000,000 airplane-miles, safely carried more than 2,250,000 passengers . . . Air Force has officially accepted Convair's delta wing research plane and designated it the XF-92A. Director of Engineering, R. C. Sebold, said research to date points to possibility that delta wing will develop into the standard configuration for supersonic flight.

• Wright Emphasis . . . In line with reorganization plans for the **Curtiss-Wright Corporation,** a new production program has been put into effect at company's engine division, Wright Aeronautical Corporation, in which greater emphasis will be placed on the manufacturing resources of the engine-building division. An increasingly large part of the facilities at that plant are being used for production of components of one of the standard jet engines for which the military air services have an immediate need. Along with the increased production program, the company will continue to carry on its research and development work in the jet engine field, while unprofitable projects, involving expenditures of about $1,000,000 per month, are being discontinued. Wright operates largest turbine-testing laboratory under private management in the industry.

• Douglas' New Price Policy . . . A 10 per cent reduction in net price of **Douglas Aircraft Company's** manufactured spare parts for DC-3, DC-4, and DC-6 transports has been announced, effective July 5. Price policy, containing certain retroactive features, was made possible by manufacturing and operational economies. Some of the latter, Douglas says, were the result of the cooperation from air lines in effecting better inventory controls and eliminations of routine correspondence. New prices effect operators of some 6000 DC-3's, 750 DC-4's, and 150 DC-6's in commercial service throughout the world.

• Magnesium in Helicopters . . . New successes for magnesium, scored in the Navy's XHJP-1 utility helicopter, built by Piasecki, have been announced by **The Dow Chemical Company.** The XHJP-1, says Dow, utilizes magnesium in transmission cases, control quadrants, the pitch arm, and other control parts. These applications, said company, required a lightweight metal and one resistant to fatigue; both of these qualifications are met by magnesium. Easy machineability is another quality giving parts improved performance.

• Huge Tool . . . One of the largest and most efficient tools in the commercial airline business has been completed and placed in operation by **Eastern Air Lines, Inc.,** in Miami, Fla. This huge tool, which Eastern calls a line maintenance building, was built at a cost of over $1,500,000, is three stories high, and has 180,600 sq.ft. of floor space under roof. Building has eight maintenance docks, four on each side, accommodating eight new-type Connies at one time. Four 2,500-hp. Wright engines can be changed in 6 hours on a Constellation. Great advantage of the new building is its ability to handle planes independently of one another. A plane is never hemmed in by one in front or behind.

• Robot Takes DC-3 Across Nation . . . Making a safe landing at Westchester County Airport early in June, a DC-3 transport completed a successful 2,778-mile test flight from San Francisco with an automatic pilot at the controls the entire distance. Owners of the plane, **Federal Telecommunications Laboratories, Inc.,** a partial subsidiary of the International Telephone & Telegraph Company, developed the automatic pilot equipment

used in the test with the aid of Minneapolis-Honeywell Regulator Company. Robot utilized an automatic coupler to translate radio beams from ground stations into "orders" for the flight controls.

• More Power for Stratojet . . . Boeing's XB-47 Stratojet, holder of the all-type transcontinental record at an average speed of 607 m.p.h., is being equipped with even more powerful jet engines with installation of **General Electric Company's** J-47 turbojets in one of two experimental XB-47's. Use of the new G-E J-47's will raise total power more than 25 per cent. Each J-47 develops more than 5,000 lbs. of thrust compared with 4,000 lbs. of J-35 turbojets. . . Company's $25,000,000 jet center at Lynn, Mass., will enable engineers to study jet engines nearly four times as powerful as those now in production, G-E says. New methods of thrust augmentation now under development and other improvements, including metals and better fuels, would make possible engines with 10,000 to 20,000 lbs. of thrust.

• "Hamstan" . . . Another sign that the days of the propeller are numbered comes from United Aircraft's **Hamilton Standard** division, which announces that henceforth, both officially and formally, it's quite all right to drop the "Propellers" from the division name. Millions of Allied airmen, says Hamilton Standard, long ago did a little shortening of their own, referring to the division and its products as "Hamstan." Company quickly points out, however, it's still very much in the propeller business, although its products go beyond the prop itself—aircraft spinners, governors, integral oil assemblies, synchronizers, and helicopter rotor parts. This year marks Hamilton Standard's 30th anniversary.

• Doubles Workers . . . **Irving Air Chute Company, Inc.,** is doubling its worker force at company plants in Buffalo and nearby Ft. Erie, Ontario. Orders have been received from U.S. and Canadian governments amounting to $2,000,000. Each parachute plant, previous to new hiring that began July 5, employed about 40 persons.

• New Auxiliary Power Plant . . . The new Jack & Heintz AP50 auxiliary power plant supplies 400-cycle a.c. power for testing instruments and controls of B-36 bombers while on the ground—without running the six 3,000-hp. engines that normally supply it with power in the air. Said to be a suitable power source wherever 400-cycle, 208/120-volt power is required, power plant is rated at 62.5 k.v.a. at 0.8 power factor. Write **Jack & Heintz Precision Industries, Inc.,** Cleveland 1, Ohio, for details.

• Aircraft Water Extinguisher . . . Civil Aeronautics Administration has granted **Walter Kidde & Company, Inc.,** approval of a new water extinguisher intended for use against Class A fires in aircraft interiors. Said to be first of type made, the Kidde water extinguisher contains $1^3/_8$ qt. of antifreeze water solution. Weighing less than 7 lbs., it operates at temperatures down to —40°F. A lightweight supporting bracket makes installation easy. Pressure for squirting a stream 20 ft. or more is provided by carbon-dioxide gas released from a small cartridge contained in the threaded extinguisher handle. Water chamber can be refilled after use from any available water supply simply by removing extinguisher top, and a new cartridge of compressed CO_2 quickly inserted in screw-on handle . . . A new aviation sales office has been opened by Kidde in Dallas, Tex.

2,000TH BONANZA DELIVERED

Beech Aircraft Corporation passed a milestone in personal aircraft construction recently when it delivered its 2,000th four-place Beechcraft Bonanza. Accepting delivery of the Bonanza personally from Walter H. Beech (right), M.I.A.S. and President of Beech Aircraft, is V. B. Likins of the Flying L Ranch, Davis, Okla.

• Hydromatic Props for New Connies . . . Hamilton Standard 43E60 reversing Hydromatic propellers have been selected by **Lockheed Aircraft Corporation** for the 20 L-749 Constellations ordered by Trans World Airlines recently.

• Martin Building Ten Vikings . . . A total of ten Navy Viking rockets will be built by **The Glenn L. Martin Company,** incorporating design modifications following the test flight of the first Viking last May.

• New Bendix Plant . . . Ground was broken for a new $250,000 building in North Hollywood by **Pacific Division,** Bendix Aviation Corporation. New plant will be used for manufacture of automotive and tractor hydraulic units.

• Stratocruiser Maintenance . . . **Pan American World Airways'** Stratocruisers are being flown from New York to Miami for maintenance at Pan Am Overhaul Base. First arrival was the Flying Cloud, which flew in for engine change and checkup. With addition of the Stratocruiser to its work sheet, P.A.A.'s Miami Overhaul Base now maintains virtually every major type commercial aircraft made in U.S. In addition to Boeings, Pan Am's world-wide Clipper fleet includes Constellations, Convairs, DC-4's, and DC-6's, all of which fly to Miami for maintenance . . . Tourist-class service, 25 per cent below first-class rates, went into effect all around South America in mid-June. Tourist trip was made possible by new joint Pan Am-Panagra twice-weekly tourist-class service between Miami and Buenos Aires via Canal Zone and West Coast of South America.

• Parker Level Control Bulletin . . Twelve-page *Bulletin 530,* just published by **The Parker Appliance Company,** 17325 Euclid Ave., Cleveland, Ohio, covers specifications and applications of the recently developed Parker liquid control valve in several types. Five diagrams illustrate typical applications of the valves to single-point servicing and underwing fueling of aircraft.

• Million Dollars in New Business . . . A million dollars in new business for its Metal Products Division has been booked by the **Ryan Aeronautical Company.** Most of it is for exhaust systems for military and commercial transport planes and stainless-steel jet engine components. Included in the contracts are those from Douglas Aircraft for a large quantity of Ryan exhaust collector systems for C-54 military and DC-4 commercial air liners.

• Gyropilots for Blimps . . . Navy Bureau of Aeronautics has ordered 17 modified A-12 Gyropilots from **Sperry Gyroscope Company** for use on blimps.

• 24,000 Families on Family Plan . . . **United Air Lines'** reduced rate family fare plan, recently extended to September 30, has accounted for almost 10 per cent of company's revenue passenger-miles since it went into effect 7 months ago. More than 24,000 families, averaging slightly more than two persons each, had used the plan as of June 14.

Meet Your Section Chairmen

Harold Vern Hawkins

Chicago Section

A request to help inaugurate a program of education in aeronautical industries for Cornell University in Buffalo, N.Y., in 1940, started Dr. Harold V. Hawkins in the aeronautical field, for it ultimately led to his joining Bell Aircraft as a Stress Analyst in 1941.

Born 36 years ago in Portland, Ore., he went to the University of Washington and Cornell University, receiving in turn his B.S. in Civil Engineering, M.C.E. and Ph.D.

▶ **Transition to Aircraft**—Engineering always provided him with a varied and most interesting career. Starting as a youth with summers spent in lumber mills and on building construction, Dr. Hawkins worked from civil engineering structures to aircraft work.

As a Stress Analyst at Bell Aircraft, he developed structural memoranda to outline methods of analyses. After performing the stress analysis on the P-63 wing, Dr. Hawkins was asked to develop a Vibrations Engineering Group and Vibrations Laboratory to cope with the critical troubles that were being experienced in flight testing.

This led into electronic instrumentation and telemetering, and, finally, he was named Chief Electronic Engineer at Bell, at which post he remained for $1\frac{1}{2}$ years. He then decided to return to his postwar profession of engineering education.

▶ **Buried Documents**—The most interesting event of his career was realized in 1945 when he spent 4 months in Europe as Technical Representative attached to the Army Air Forces, assisting in the assessing of the German aircraft industry, the Messerschmitt company in particular.

In that time, Dr. Hawkins traveled some 22,000 miles, digging up buried documents, opening safes "the hard way with a chisel," and groping through tunnel factories that the Germans built to escape the day-and-night attacks of American and British air forces.

Now Professor of Civil Engineering at Illinois Institute of Technology, where he conducts courses in airplane stress analysis, design, and aerodynamics, Dr. Hawkins, who is a Past-Chairman of the Buffalo Section of the Institute, was recently elected National President of Tau Omega, aeronautical honorary fraternity. He is also a member of Tau Beta Pi, Sigma Xi, Phi Kappa Phi, Chi Epsilon, American Society of Civil Engineers, and the National Society of Professional Engineers. He has professional Engineers' Licenses in both Illinois and New York.

▶ **Paper on Vibration**—In 1946, at the I.A.S. Annual Meeting in January, Dr. Hawkins gave a paper on "Trouble Shooting with Vibration Equipment."

In addition, he has written "Pipe Line Flexure Stresses Caused by Expansion or Movement of Supports," which appeared in *Marks' Mechanical Engineers' Handbook*, and "Big Deflections," that came out in the *Cornell Engineer* of January, 1937.

Married, Dr. Hawkins has two girls, aged 3 and 7. For relaxation he retires to his "repair shop" in the basement of his home. There with saws, drills, solder, and meters, he fixes radios, broken toys, and other household mechanical casualties.

James C. Floyd

Toronto Section

As Project Designer in charge of design work on the Avro C-102 Jetliner, now in process of completion by A. V. Roe Canada, James C. Floyd finds his present work the most interesting in his career and, since coming from Great Britain in 1946, finds living in North America extremely pleasant, thoroughly enjoying the "reasonably predictable weather as compared to the somewhat unpredictable climate in the north of England."

Born 34 years ago in the north of England, he was educated at the Manchester College of Technology. He received the Higher National Certificate (1935) and the Associateship Manchester College of Technology (1936) awards, in addition to an Associate Fellowship of the Royal Aeronautical Society (1939) while in England. In 1947 he became a Member of the Institute.

▶ **Experimental Flights**—In England, where he spent a number of years with the A. V. Roe firm at Manchester, Mr. Floyd participated in many experimental high-altitude flights in a Lancaster bomber and made the first flights on the York commercial transport. He served as Liaison with the Royal Aircraft Establishment and Avro at Farnborough, England, test center.

He also served on the Aeronautical Research Sub-Committee on Structures at the National Research Council in Ottawa from 1946 to 1948. He was re-elected to serve a further 2-year term, 1948–1950.

Among the technical papers Mr. Floyd has given were "Design Problems of a Prototype," before the Student Branch and Toronto Section of the I.A.S., and "Design Development of the Avro C-102 Jet Transport," which he presented at the Annual Convention in Quebec, May, 1949, of the Engineering Institute of Canada. He also has written "Destiny of Jet Transport" which appeared in *Canadian Aviation*, May, 1948.

On a trip to California for an S.A.E. meeting last fall, Mr. Floyd was able to indulge his hobby of photography to the full in taking pictures of the Grand Canyon on the way. In the summer he likes to photograph Canadian wild life and many unusual things around the countryside. In addition, he has been doing some personal plane flying with a private club, having logged some 10 hours, although he hesitates to describe himself a pilot.

In the winter he and his family get in as much skating and skiing as possible.

I.A.S. Sections

Chicago Section

Alfred Stott, *Secretary*

Chief of Aerodynamics, David S. Lewis, of McDonnell Aircraft, presented a paper on "Recent Trends in the Design of High Speed Aircraft" at the meeting of May 17. Harold V. Hawkins, Chairman, presided with 42 members present.

▸ **"Little Henry"**—Before giving his talk, Mr. Lewis made a few opening remarks and showed two color sound films, one of Little Henry, the ram-jet-propelled helicopter, and one of the Banshee, Navy jet fighter.

Following the films, the speaker described the probable trends in the design of high-speed aircraft with regard to sweep, stall, and drag characteristics through the various speed ranges. A brief comparison was made between planes using straight and swept wings with regard to performance, aerodynamics, and structural considerations.

Cleveland-Akron Section

William A. Fleming, *Secretary-Treasurer*

At the May 31 meeting, 120 persons were present for the annual election of officers and to hear Dr. A. Kossiakoff, Associate Director, Applied Physics Laboratory, Silver Spring, Md., on the subject "Advances in Guided Missiles Research."

New officers elected were: Chairman, Arch T. Colwell; Vice-Chairman, Cleveland, Dr. S. Doree Black; Vice-Chairman, Akron, Hans Peter Liepman; Secretary-Treasurer, William A. Fleming. Advisory Board consists of the following: Abe Silverstein; Eugene E. Wasielewski; Dr. Robert S. Ross; John H. Collins, Jr.; Oscar W. Loudenslager; Jack D. Peace, Jr.; Howard F. Powders; and E. W. Cleveland.

▸ **Deals with Each Research Stage**—Dr. Kossiakoff dealt with each stage of the research and development of the current ram-jets and rocket-powered vehicles, illustrating them with films.

A talk by Dr. R. K. Dalstrom, Chief of Propulsion Research & Development, Applied Physics Laboratory, followed.

Philadelphia Section

Dale Hamilton, *Secretary*

New officers elected by the Section are as follows: Chairman, Alfred L. Wolf; Vice-Chairman, Hugh Mulvey; Secretary, Dale Hamilton; and Treasurer, W. Colcord.

Council Members are H. R. Young, J. A. Roy, J. S. Kean, F. G. Tatnall, R. McLarren, L. Cheesman, H. S. Campbell, and P. H. Stanley.

San Diego Section

W. T. Immenschuh, *Secretary*

With 110 members holding a dinner meeting in the new I.A.S. Building on Harbor Drive, W. L. Howland, Flight Services Engineering Supervisor, Lockheed Aircraft, gave a talk on "Flight Test Methods and Procedures." Vice-Chairman Dwight Bennett presided.

▸ **Flight Test Cost**—The speaker emphasized that the high cost of flight testing makes it increasingly important that every minute the plane is in the air must be utilized to obtain as much research data as possible.

Howland estimated that the overall costs of flight testing, reduced to costs per hour of operation, are about $3,000 for a large air-liner type plane, and $1,000 per hour for a military fighter type.

Order of testing is usually engine cooling and operational checks, followed by preliminary stability and control characteristics. Having obtained satisfactory performance, Howland said, detail examination based on customer requirements and specifications, with simultaneous testing of design group requirements such as cabin supercharger and hydraulic system, etc., follow.

It is considered that a capable engineering flight observer becomes competent only after 200–300 hours of flight time to be able to obtain data during the many flight conditions that prevail.

▸ **Measuring Equipment**—As for installation of measuring equipment, Howland said, it is now standard practice to install force-measuring units on all flight controls to eliminate variable human judgment and to install position indicators on all movable surfaces, landing gears, cowl flaps, etc., so that a record is obtained of the condition of the airplane, particularly during speed evaluation.

Installation of strain gages on all major load-carrying members has become increasingly valuable not only in obtaining internal structural data but also by affording a warning through a light signal to the pilot when the structural limitation of the aircraft is being approached.

Considerable development, said the speaker, has prompted the use of strain-gage measurement on wing panels to determine spanwise load distributions, adding that good correlation has been obtained between theoretical calculations, wind-tunnel measurements by pressure orifices, and the strain-gage method.

However, he explained, special considerations are necessary to obtain accurate data, since one must get static load calibration by percentage incremental load applications prior to flight and such other conditions that affect strain-gage installations. It has been found necessary on occasion, Howland said, to make flights at night to eliminate temperature effects due to solar radiation on the wing panels.

Student Branches

Brown University

Student Branch members made a field trip on May 19 to the Aeroproducts Division of General Motors, Dayton, Ohio. At the plant, the process of making propellers from beginning to finished product was shown.

In the afternoon, following a lunch in the company cafeteria "on the house," members toured Aeronca Aircraft at Middletown.

On the following day a visit to Wright-Patterson Air Force Base was made, in which design labs, wind tunnels, and engine labs were inspected. In addition, after a noonday meal at the Officers Club, the members visited the Base's flight line and toured the Static Test hangar where a B-36 was undergoing tests.

On June 1, Dr. John R. Weske, Honorary Chairman, led the discussion on a proposed series of flight tests of a small plane to be made by the Branch in conjunction with the Flying Club, Brown University, and Air Brown, Inc.

Cal-Aero Technical Institute

The June 7 meeting featured a talk by Felix W. A. Knoll, Rocket Research Engineer, Frank Mayer & Associates, on the subject "The Design of Satellite Rockets."

Chairman A. C. Reid told of two committees to be formed in the Branch: the Meetings Committee and the Membership Committee. The first, composed of Dale Daniels, Rick Wilkins, Joseph Ferrell, and Ralph

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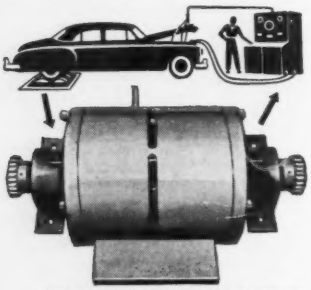

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Hulick, is to be responsible for invitations to guest speakers. The Membership Committee will be responsible for all new Student Members, as well as the sale of I.A.S. pins. It is composed of Robert LeVand and Don Tower.

Case Institute of Technology

The following new officers were elected at the May 17 meeting: Chairman, Raymond S. Wagner; Vice-Chairman, Henry H. Holmitz; Secretary, Samuel Black; and Treasurer, Robert Chirakos.

Films of the 1947 and 1948 National Air Races were shown. Claude Leibensberger presided as Chairman.

Cornell University

New officers elected at the May 17 meeting were: Chairman, Laurence E. Fogarty; Vice-Chairman, Alfred Ritter; and Secretary, Jean McDonald.

Iowa State College

At the May 19 meeting, members elected George D. Stilley, Chairman; Glenn M. Minott, Vice-Chairman; and Howard W. Axtell, Secretary-Treasurer.

Massachusetts Institute of Technology

A field trip was made May 4 to the nearly completed wind tunnel by 68 members of the Branch.

The tunnel is a closed-return channel, powered by electric motors driving two five-stage centrifugal compressors. The two compressors will supply a pressure ratio sufficient to operate the tunnel over a Mach Number range of 1.2 to 4. Power input to 10,000 hp. will permit a maximum stagnation pressure of approximately 60 lbs. per sq.in. at Mach 4. Reynolds Number variation over a large range can be obtained by changes in the tunnel density.

A by-pass arrangement has been built into the tunnel to permit idling of the compressors while changes are being made to the models in the working section.

The building for the project is a "T" arrangement. Every effort was made to get maximum noise absorption inside the building. It is expected that the acoustic design will result in a noise level of 40 db. just outside the walls of the compressor room. The 40-db. level is the ambient noise level due to street traffic in the lab area.

New York University

Newly elected officers at the May 16 meeting are: Chairman, Robert J. McCormick; Vice-Chairman, Arthur H. Bertapelle; Secretary, Ernest A. Weil; Treasurer, Irving Shantz.

Professor F. K. Teichmann continues to serve as Honorary Chairman.

North Dakota Agricultural College

The Student Branch participated in the activities of the School of Engineering Open House on the campus during the afternoon and evening of May 19–20.

The Branch sponsored a display of college equipment and other material in the temporary Aeronautical Engineering Quonset building. On exhibition were the Junior Laboratory's AT-6 and four heavy aircraft engines, ditching and spinning-tunnel models, a research rocket loaned by N.A.C.A., a large working model of a turn indicator, and a propeller display, part of which was loaned by the Sensenich Corporation. Two films were shown continuously concurrently with the exhibit.

A field trip to University of Minnesota Research Center at Rosemount was made May 28, where a group of seven was conducted through the Aeronautical Engineering Department.

On June 2, an election of officers was held with the following results: Chairman, Philip Akin; Vice-Chairman, Arthur Stennes; Secretary and Treasurer, Albert Mahrer.

Northrop Aeronautical Institute

At a dinner meeting held June 1, the newly elected officers were introduced: Chairman, B. I. Person; Vice-Chairman, R. B. Booth; Secretary, L. T. Parson; Treasurer, R. D. Moore.

Dr. Walter Riedel, Consulting Engineer, North American Aviation, gave a talk on "Development of German Rockets and Guided Missiles."

University of Notre Dame

At the May 19 meeting, Chairman Geudtner reported on the formation of the Student Engineering Council, the function of which is to aid the engineering magazine, the Engineers' Ball, and other activities beneficial to the entire college.

New officers elected were: Chairman, Walter Geudtner; Vice-Chairman, Robert Kraemer; Secretary, Peter Skerrett; Treasurer, Timothy Hanrahan.

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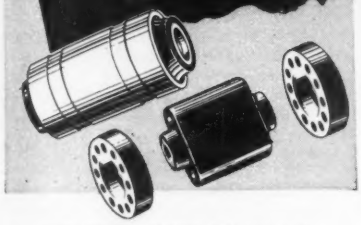

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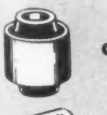

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Oregon State College

With Chairman Curt Privett presiding, a film, *Report on Jet Propulsion*, was viewed by 15 members present at the May 18 meeting.

Following the film, Stan H. Lowy, Oregon State Aeronautical Engineering Instructor, gave a talk on "Jet Propulsion." He discussed three principal types of jet engines: the pulsejet, ram-jet, and turbojet.

Parks College of Aeronautical Technology

At the meeting of June 2, LeRoy Varga, graduating engineer of Parks College, gave a talk on "The Photoelastic Stress Analyzer."

In studying stresses, Mr. Varga concentrated on failures in the Ercoupe due to strain on the structure resulting from high impact landings.

The Pennsylvania State College

The meeting of May 6 was attended by 110 students to hear Michael Cozzolli, Assistant Design Engineer, Fairchild Aircraft Division, on the subject of the "Relation of Cargo Airplanes to Military Forces." John Kutney, Chairman, presided.

The annual banquet of the Student Branch was held on May 11, at which Mellville Hopkins, Professor of Speech, was the principal speaker. His subject, "The Articulate Engineer," was well supplemented with amusing anecdotes. Professor Hopkins stressed the importance of correct exposition.

Polytechnic Institute of Brooklyn

"Suction Airfoils" was the topic taken by Harry Heyson, Thesis Student, at the May 3 meeting, attended by 62 members. Chairman Donald E. Platz presided. The speaker described the theory underlying the unusual shape of suction airfoils of the type development by A. A. Griffith in England.

University of Southern California

A joint meeting with the A.S.M.E. was held on May 19 with Harry Gann, I.A.S. Student Branch Chairman, presiding.

Dr. Fritz Feldmann, Group Leader, Supersonic Wind Tunnel, North American Aviation, spoke on the "Design and Operation of the New Supersonic Wind Tunnel." A color film of the wind tunnel was shown.

(*Continued on page 100*)

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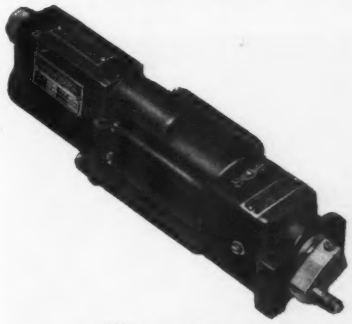

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News of Members

George A. Anderson, Jr., T.M.I.A.S., has joined Boeing Airplane Company (Seattle) as Junior Engineer. He was with Northrop Aircraft.

Richard S. Boutelle, M.I.A.S., a Vice-President and Director of Fairchild Engine and Airplane Corporation, severed his connection with the company and is associating himself with Sherman Fairchild. Employees at the Airplane Division, Hagerstown, Md., plant met at the airport in a brief ceremony at which he was presented with a placque "in appreciation for his leadership" and "for the many things he has done for the welfare of his employees."

Kenneth P. Bowen, M.I.A.S., Assistant General Manager, Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation, has been named Acting General Manager of the Division in place of Richard S. Boutelle.

John E. Burkam, T.M.I.A.S., resigned from Piasecki Aircraft and is Project Engineer with Duncan & Bayley, Inc., Buffalo, working on high-speed servos and model helicopters.

Alexander M. Carey, T.M.I.A.S., has changed from Test Engineer at Pratt & Whitney Aircraft, East Hartford, Conn., to Flight Test Engineer, Naval Air Station, Patuxent River, Md.

L. A. Comp, M.I.A.S., Chairman of Department of Aeronautical Engineering, University of Oklahoma, was elected National Vice-President of Tau Omega, national honorary aeronautical engineering fraternity, at the annual convention held at Illinois Institute of Technology.

VICKERS APPOINTMENT

Benjamin W. Badenoch, M.I.A.S., has been appointed Aircraft Products Application Engineer for the Los Angeles area by Vickers, Inc., Detroit, Mich., subsidiary of The Sperry Corporation. Mr. Badenoch, who received his aeronautical engineering degree from M.I.T., was with Douglas Aircraft (El Segundo) for 6 years. Previously he was with Vega Aircraft.

PIASECKI CHIEF ENGINEER

Lee Douglas, M.I.A.S., former Chief Engineer and General Manager of Kellett Aircraft Corporation, has been named Chief Engineer with the Piasecki Helicopter Corporation, Morton, Pa. Starting with Kellett in 1944 as Chief Structural Engineer, Douglas assisted in the work that led to Kellett receiving considerable Air Force business, and he was named Chief Design Engineer early in 1946. He became Chief Engineer later that year and was made General Manager of Kellett in the latter part of 1948.

Robert H. Essig, M.I.A.S., recently was employed by Ohio State University Research Foundation as a Research Associate. New address is 316 W. Lane Ave., Apt. B, Columbus 10, Ohio.

Donald P. Frankel, M.I.A.S., resigned as Power Plant Engineer with Douglas Aircraft to become Chief, Components Expediting Branch, Aircraft Scheduling Unit (MCLASU), Wright-Patterson Air Force Base, Dayton, Ohio.

Captain Harold E. Gray, M.I.A.S., Manager of Pan American World Airways' Pacific operations, was elected a Vice-President at a meeting of the Board of Directors.

John F. Haines, M.I.A.S., has entered private practice as a consulting engineer. Formerly Director of Research, Aeroproducts Division, General Motors Corporation, he has had 15 years' experience in experimental and production design. Office is at 11 West Monument Building, Room 703, Dayton 2, Ohio.

H. Kestenberg, T.M.I.A.S., is a Stress Engineer with the Israel Air Force. Address is 4, Gnessin Str., Tel-Aviv, Israel.

John W. Lawton, M.I.A.S., is now at the Westinghouse Electric office, McDonnell Aircraft Corporation, Robertson, Mo.

Lieutenant W. H. Livingston, U.S.N., T.M.I.A.S., is now assigned to Flight Test Division, N.A.T.C., U.S. Naval Air Station, Patuxent River, Md.

Captain Benjamin B. C. Lovett, T.M.I.A.S., is attending the Industrial College of the Armed Forces, Washington 25, D.C. He formerly was Staff Commander, Naval Forces Western Pacific, based at San Francisco.

Leslie Morley, T.M.I.A.S., is Technical Assistant with The Bristol Aeroplane Company. New address is 18, Upper Belmont Road, Bristol 7, England.

John A. Parchem, M.I.A.S., Assistant Professor of Aeronautical Engineering, University of Notre Dame, is on leave of absence until September 1, 1950. Starting June 1, 1949, he has been employed as an engineer at the University of Michigan Willow Run Supersonic Wind Tunnel. At the same time he has been carrying on graduate studies at Michigan.

Major C. J. Price, M.I.A.S., is on the staff of the Division of Civil Aviation, Department of Transport, Union of South Africa, as a Senior Inspector of Aircraft. Address is Private Bag 176, Division of Civil Aviation, Department of Transport, S.A. N.L.A.M. Buildings, Pretorius St., Pretoria, South Africa.

Daniel E. Shafer, T.M.I.A.S., is now in the Engineering Department of Boeing Airplane Company, Seattle. Home address is 3420 Florence Court, Seattle, Wash.

Admiral John H. Towers, U.S.N. (Ret.), M.I.A.S., pioneer Naval airman who joined Pan American Airways in 1948, was elected a Vice-President by the Board of Directors recently.

Gene H. White, T.M.I.A.S., is with Saval, Inc., as Assistant Eastern Engineering Manager. New address is 260-13 Union Turnpike, Floral Park, L.I., N.Y.

INSPECTING HIS HANDIWORK

C. L. "Kelly" Johnson, F.I.A.S. and famed Chief Research Engineer of Lockheed Aircraft, inspects new Lockheed F-90 jet penetration fighter of U.S. Air Force prior to its taxi tests in Burbank. Combining speed, range, and maneuverability, new plane will roam far behind enemy lines, seeking out specific military objectives and targets of opportunity, according to Lockheed. The swept-wing fighter is powered by two turbojet engines.

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Guest Editorial

International Amenities

The following excerpts are taken from the addresses by the presidents of the two Societies at the opening of the I.A.S.-R.Ae.S. Second International Conference.

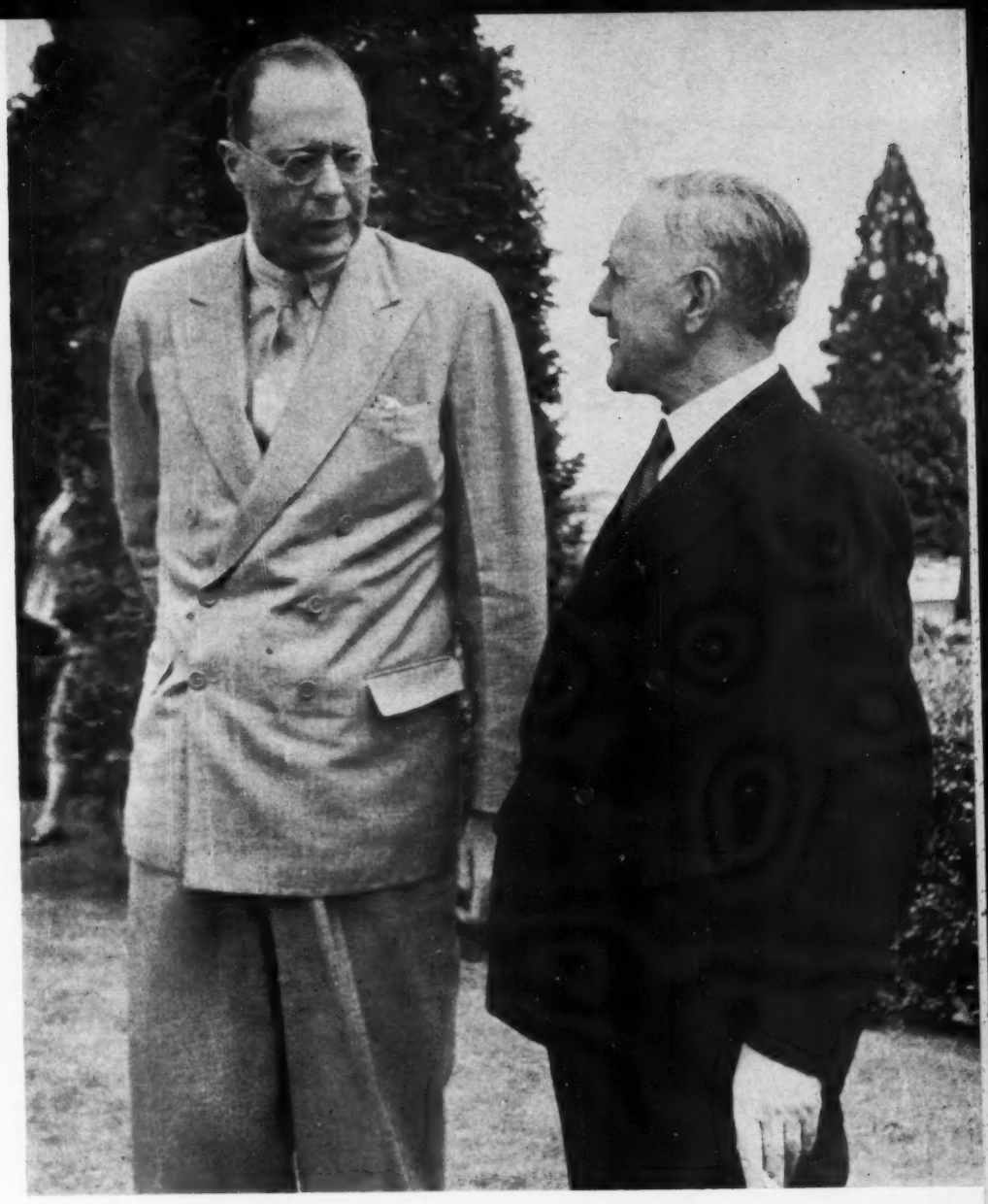
Mr. Burden

I can imagine no more pleasant duty than acting as spokesman for the Institute in welcoming our friends from the Royal Aeronautical Society to the Second Joint Conference between the two organizations. It is a commonplace of aeronautical engineering that it is wise to build and test a prototype before embarking on serious production. Our Institute is most fortunate in having the benefit of the excellently designed and beautifully executed first joint meeting organized by the Royal Aeronautical Society in the Fall of 1947. That was really a good prototype. I am certain that this first production example, which we open formally today marks the beginning of a long line of useful articles that will defy the usual aeronautical bugbear of obsolescence. On the technical front, the parallel with the previous meeting is very close. Twenty-three papers, which will be read and discussed in the next 3 days, treat a carefully chosen group of problems, all in the main stream of aeronautical development. The selection is based on the same criteria of urgency and basic importance that we used in picking subjects for the London meeting. In several cases, the propeller gas-turbine problems induced by supersonic speeds and helicopter development are outstanding examples.

A British or American engineer is now reporting progress during the last 20 months in a field that was discussed at our London meeting. This consistent trend clearly illustrates the importance of continuity in these joint meetings. I have every confidence that the discussion will be as free and animated as it was in England. The aeronautical profession has certainly risen above Bernard Shaw's definition of discussion as a method of rearranging one's prejudices.

I was particularly delighted that we had some excellent discussions starting at our informal meeting at the Institute last night. There were some good arguments that began there which I know will be continued over the next 2 weeks. We may not convince each other, but I am sure that we will know a lot more about our subjects as a result. In the field of less serious activities, we will depart somewhat from the precedent set in London. We could not possibly surpass our British friends in the excellence or intensity, if I may use the term, of their hospitality. We'll try to send you home not completely exhausted but about 80 per cent exhausted and, we hope, happy. Unfortunately, we have no historic London, no Guildhall, and no Lord Mayor to warm the chockles of weary conferees' hearts. Skyscrapers, the Great White Way, the theater, and the greater diversity of cities and towns must take the place of the attractions of our parent civilization.

The social events that our busy program permits have been designed to bring you as much as possible into our homes, where, in an atmosphere of relaxation, we can cement the bonds that common technical interests have already created. We particularly hope to meet together under such conditions over the long Memorial Day week-end, the period when you will



find New York as deserted as London on a bank holiday.

In closing these remarks, I wish especially to welcome Sir John Buchanan, the President of the Royal Aeronautical Society, and Captain J. Laurence Pritchard, the able Secretary, who has guided its development for so many years and welcomed so many American visitors to its ample facilities. Sir John's record is an extremely distinguished one. He has held many key positions in government, including that of Director-General of Aircraft Production, and had also held important posts in the private aeronautical manufacturing industry in England. He is also, as you will dscover as you get to know him better, a very genial, pleasant, and amiable gentleman, with, I would suspect, a good deal of Scots' blood. I should like to introduce Sir John.

Sir John Buchanan

Mr. President and gentlemen. I have very little to say except to thank you, Mr. President, for your very kind welcome to us today and to say how glad we of the Royal Aeronautical Society are to be here and to hear these papers. I join with you, sir, in making confession that these meetings are to some extent trials, but we are quite sure that they will go on from time to time in greater and greater success. I should like also to take this opportunity of thanking the able staff of the Institute for the care that they have taken of the temporary immigrants into the United States, finding us adequate accommodation and ensuring us a most excellent hospitality. I wish every success to this Second International Conference. Thank you, gentlemen.

Technical Sessions of the I.A.S.-R.Ae.S. Second International Conference

by

John J. Glennon

Power Plants

THE TECHNICAL SESSIONS of the I.A.S.-R.Ae.S. Second International Conference got under way at the Hotel Astor on Tuesday morning, May 24, with the presentation of three papers on the design and operation of power plants. The first paper was devoted to that class of power plants which requires air for combustion. This class covers all types of aircraft engines except rockets and includes both reciprocating and turbine engines. The last two papers were concerned entirely with the problems of gas-turbine power plants. E. S. Taylor, Professor of Aircraft Engines, Massachusetts Institute of Technology, presided as Chairman. Summaries of the three papers read at this session follow.

Optimum Fields of Application for Air-Consuming Aircraft Power Plants

W. G. Lundquist, Chief Engineer, and **G. S. Kelley, Jr.,** Assistant Project Engineer, Wright Aeronautical Corporation

The aviation industry has been undergoing a fundamental upheaval in design and engineering since the advent of practical gas-turbine and rocket-type power plants, and there has been an uncertainty regarding the types and sizes of power plants most suitable for development. While it is not possible at this time to deduce the exact nature of future aircraft operations, it is of paramount importance to establish a power-plant development plan of sufficient scope and flexibility to be adaptable to a continuously changing aircraft program. It is the purpose of this paper to present a method of determining optimum types of power plants. The conclusions resulting from application of this method are given within the limits of military security regulations.

As indicated by the title of this paper, the discussion pertains to a particular class of aircraft power plants—namely, those that consume air. This covers everything except rockets and includes both reciprocating and turbine-type engines. In addition, the discussion is confined to true air-borne vehicles.

The method proposed herein for determining the optimum range power plant consists of the evaluation of the relative utilization of the fuel energy by the various types of power plants at various speeds. Conclusions are based on the premise that the best power plant for any application involving range is the one that has the lowest total losses, or conversely, the one that has the highest percentage of fuel energy available for useful propulsive work.

Such an analysis has been conducted on reciprocating engines, reciprocating compound engines, turboprops at several compression ratios, turbojets at several compression ratios and degrees of afterburning, and ramjets. Several figures showing the energy balance of reciprocating engines are given to represent the results obtained by this method of analysis.

General conclusions are presented, and the future possibilities of the compound reciprocating engines are discussed.

In summarizing, the authors point out the necessity for careful future planning with regard to power-plant development because of the increasing development costs and the necessity for the development of several engine types. A great deal of money, effort, and time will be lost in duplication and blind-alley developments if a well-planned program is not carried out.

(*Left*) First Technical Session, Tuesday Morning, May 24. *Left to right:* E. S. Taylor, Professor of Aircraft Engines, M.I.T., Chairman; W. G. Lundquist, Chief Engineer, Wright Aeronautical Corp.; F. M. Owner, Chief Engineer (Engines), Bristol Aeroplane Co. Ltd.; N. Burgess and J. C. Buechel, Aircraft Gas Turbine Division, General Electric Co. (*Right*) Luncheon, Tuesday, May 24. *Left to right:* W. A. M. Burden, President of the I.A.S.; T. P. Wright, Vice-President—Research, Cornell University, Guest Speaker; Sir John Buchanan, President of the Royal Aeronautical Society.

The Propeller Gas Turbine in Service

F. M. Owner, Chief Engineer (Engines), Bristol Aeroplane Company, Ltd.

This paper, which is the third of a series presented by the author in the last 2 years, reports on the experience gained in the first thousand engine-hours or so of operational use of the Bristol Theseus propeller-turbine engine by the Royal Air Force Transport Command over the England–Egypt run. It commences with a summary of the case for the development of the propeller turbine, followed by a description of the genesis and special characteristics of the Theseus, on which most of the Bristol flying experience to date has been gained. A discussion of the relative advantages of the "free" turbine illustrates that the propeller-turbine will show an advantage in efficiency over the pure jet up to 500 m.p.h. Next, in order to assess the results to be expected from the flight testing, a description of the methods and results of bench testing is given, and a review of some of the problems of bench testing is included. A particularly important item coming under this heading is the form of statement and interpretation of the results obtained. Methods adopted for flight testing and correcting observed data are examined.

A description then follows of the Theseus-Lincoln aircraft in service and of preliminary crew training. This is followed by details of the performance of the machines and their engines during the first and subsequent operational flights. The excellent mechanical condition of engines after 212 hours of flying is shown in a detailed strip report illustrated by numerous photographs. The next section of the paper contains a review of the lessons learned from this initial operational experience, and the paper is concluded by an examination of some of the problems remaining to be solved, together with appropriate methods of attack.

Overhaul costs, in spite of long life between overhauls, will be economical in comparison to piston-engine experience. This is substantiated by the fact that the initial engines have reached a "life" of over 200 hours with virtually no maintenance whatsoever, and, in final form, a long life between overhauls may be expected. Improvement in operating characteristics, such as reduced fuel consumption, ease and simplicity of control, and satisfactory functioning in climatic conditions, should be achieved within a relatively short period. Oil consumption was trifling throughout 200 hours of flying and was less at the end of this period than when the engine was new. The complete absence of vibration and the lack of noise audible in the fuselage will undoubtedly provide a new standard of comfort and lack of fatigue for passenger travel in civil air lines. The further development of the engine is proceeding, and provision is being made for icing protection, reversing propellers for braking, gear boxes, and cabin-blower drives. It should be possible to achieve a substantial further reduction in fuel consumption by proper matching and detailed design of the various sections of the engine, without going beyond the stress and temperature limitations covering the body of satisfactory operational experience. Turbine-inlet temperature and compression ratio must also be raised.

Recent Design Refinements in Turbojet Engines

N. Burgess and **J. C. Buechel,** Aircraft Gas Turbine Division, General Electric Company

This paper describes the investigations made in the writers' company on: (1) the protection of the engine

against the formation of natural ice at the inlet to the compressor and (2) the incorporation of means for thrust augmentation. The latter, while of less general importance than anti-icing, may find increasing application to aircraft of all types for take-off and emergency use.

Ground, wind-tunnel, and flight tests under actual and simulated icing conditions have established that a turbojet engine can be rendered inoperative in a matter of minutes. Compressor components at the inlet of an axial-flow turbojet engine such as the inlet guide vanes and inlet screen readily accumulate ice accretions under meteorological icing conditions. The application of heat may be such as to maintain around the affected parts an ambient temperature above the freezing point of water or to maintain the temperature of the affected parts themselves above the freezing point of water. Mechanical devices such as retractable inlet screens are also possible.

The studies have been concentrated on the use of mechanical devices and the use of heat to raise the temperature of the affected parts themselves by thermal and electrical means. Available heat transfer data giving Reynolds Number as a function of Nusselt's Number were used. Adequate anti-icing protection can be effectively accomplished through the use of internally heated hollow parts.

Use of water injection for reciprocating engines was first found desirable during World War II to increase power available within the detonation limits of available fuels. It has since received general recognition and is currently being employed in commercial, as well as military, operations. The manufacturers of turbojet engines have been called upon by air-frame manufacturers and the military services for higher thrust outputs, and they are devoting considerable effort to the augmentation of the basic engine. Investigations in the writers' company are devoted at present to two methods: water injection into the combustion chambers and exhaust reheat, or afterburning. Combustion-chamber water injection was selected as a means of obtaining modest amounts of augmentation primarily for take-off use. Its principal advantages are its simplicity with regard to installation and control and the absence of any measurable effect on engine performance during normal operation. Methods used for injection of water and control of its operating cycle are discussed, together with qualitative results as to the performance being obtained. Exhaust reheat was selected as an alternate, particularly for flight use, because of the larger gains that can be obtained in engine thrust and because the total specific liquid consumption is substantially less than with water injection. Information is presented on the methods employed in the exhaust system, together with qualitative data on performance. Either method is mechanically practicable and suitable for aircraft use in those applications requiring extra thrust at the expense of high total liquid consumption.

T. P. Wright Addresses Luncheon Group

AT THE LUNCHEON held in the Hotel Astor, Tuesday noon, T. P. Wright gave an informal address of welcome to the delegates. In extending the hospitality of the Institute to the members of the Royal Aeronautical Society, Mr. Wright stated that it was "an absolute must" that the joint conferences continue to be held regularly in the future if the two countries are to maintain their lead in the aeronautical sciences. "The nation that is on its toes in research and development has little to fear from the technological standpoint from any copyist nation," he said. "There is great benefit to both of us in these cooperative meetings that we're holding and in the exchange of missions and exchange of visits that take place constantly through the year. This applied not only during the war that we have just experienced, but it applies also in peacetime.

"Our development and design have caught up with our fundamental research. The barrel is fairly dry of fundamental information, and the designers are breathing down the necks, so to speak, of the scientists who are engaged in research and are pushing them on at a little faster rate than they really like to be pushed. The long-haired scientist likes to cogitate and think over things and not give results, but he has to give them out sooner now because the art is moving so rapidly.

"The human element . . . . is becoming more and more important, and . . . . the educational process itself must be so established as to meet the needs of the time, particularly in our field of aeronautics." The applied research conducted in commercial laboratories and in Governmental and company laboratories "is something that always must come after fundamental truths have been discovered in the universities or the institutions."

Speaking of the system of air navigation and landing aids currently being employed in the United States, Mr. Wright mentioned a report that "something like 50 per cent improvement in the reliability and also in the safety of aircraft" had been achieved during the winter of 1948–1949 in comparison with what had been done during the winter of 1947–1948. He attributed a great deal of this improvement to the fact that allowable minimum ceilings at airports could be lowered.

Mr. Wright declared that the engineers and scientists of both countries must not fail to retain "courage to face changes, courage to face new needs, and courage to attack problems that may at the moment seem insurmountable."

Helicopters and Turbine-Engined Transports

THOSE ATTENDING the afternoon session, at which Robert M. Stanley, President of Stanley Aviation Corporation, was Chairman, heard G. R. Edwards, Chief Designer of Vickers-Armstrongs Ltd., review the

progress of turbine-engined transport aircraft and examine their probable future development. Also read at this session were two papers on helicopters. The first of these, by H. B. Squire, was a report of research conducted at the Royal Aircraft Establishment on tandem-rotor helicopter stability. The second was Clarence M. Belinn's factual account of the history and current accomplishments of the scheduled helicopter airmail service operated by his company to serve the residents of the Los Angeles district.

Turbine-Engined Transport Aircraft

G. R. Edwards, Chief Designer, Vickers-Armstrongs Ltd.

The purpose of the paper is to review the progress and promise of turbine-engined transport aircraft by assessing the different types of turbine engines available, by considering their application to the principal classes of transport, and by examining in detail the technical and operational problems involved.

After a brief résumé of the available engines and an account of the aircraft that have flown with them, a comparative analysis between piston engines and the new power units is made, mainly on the score of economy, comfort, and safety. Some of the conclusions of this analysis are that, for short- and medium-range aircraft, the propeller turbine will be slightly more economical than the piston engine, with increasing improvement as the fuel reserves are reduced; that the introduction of propeller turbines will reduce the time of journey by one-third; and that, on long ranges of about 2,500 nautical miles, there is little choice between the cost of operation of pure jets, propeller turbines, and compound engines, which are all still more economical than piston-engine types. The use of pure jets will reduce the time of the journey to half, but considerable high-altitude research is necessary to make this practicable. Pressure cabins must be designed with as much attention as the wing and other major components if the aircraft is to fly at the altitude of optimum fuel consumption. A propeller turbine is just as economical as the jet on long ranges and offers a reduction in time of journey of two-thirds that offered by the piston engine. As no altitude development is needed and engines are well proved, the propeller turbine is likely to replace the piston engine on long routes.

There follows a close study of some of the chief problems involved in adapting turbine engines to transport-aircraft requirements. These include temperature accountability, effects of altitude, comfort, noise, vibration, safety, crash behavior, reduction of accident rate, installation problems with such parts as nacelles and tailpipes, ventilation, anti-icing, and the electrical system. Some of the problems encountered in the installation of the Rolls-Royce Nene engine in the Vickers Viking transport are examined briefly. A detailed survey is made of certain taxiing, take-off, and flying problems peculiar to turbine-engined aircraft as distinguished from the pure jet engine, such as starting, single power-lever control, methods of reducing windmilling drag, throttle response, maximum and cruising r.p.m., landing, dynamic effects due to failure of one engine, and overspeeding on take-off.

Most of the technical difficulties are well on the way toward solution. The economy of turbine engines—in particular, propeller turbines—compares favorably with that of piston engines, and in travel comfort and safety they are far superior. This is qualified by the opinion that, until flight control techniques are drastically overhauled, the pure jet will remain at a disadvantage for civil transports but that the era of the propeller turbine has already arrived and will immediately set an entirely new standard in air travel.

Research on Helicopters at the R.A.E. with Special Reference to the Stability Multirotor Helicopters

H. B. Squire, Aerodynamics Department, Royal Aircraft Establishment

Commercially successful helicopters must be able to carry sizeable pay loads, and, to meet this demand, they must be built with large rotors or have more than one lifting rotor. The large rotor has structural problems because of the blade flexibility when the rotor is not rotating, and it is likely to give difficulties in connection with vibration. The problems of the multirotor helicopter, on the other hand, are mainly aerodynamic in character.

The evaluation of the stability characteristics of multirotor helicopters requires an understanding of the forces acting on a single rotor and of the field of flow near it. During 1948, extensive tests were made in the 24-ft. open-jet wind tunnel at the Royal Aircraft Establishment with a rotor of 12-ft. diameter with untwisted blades of 6-in. chord. Plain flapping and drag hinges were fitted to the blades. A 25-hp. electric motor was used to drive the rotor at a tip speed of 380 ft. per sec. Measurements were made of thrust, torque, and backward tilt of the tip-path plane (first harmonic of the flapping motion) for blade angles of 4°, 8°, and 12° for a range of shaft angles from 0° to 25° and for a range of tip speed ratios from 0 to 0.45. Measurements of the forces on the rotor, the induced velocity field of the rotor, and interference between two rotors are analyzed and compared with the calculations. Agreement between theory and experiment is good for the force measurements up to the stall on the retreating blade but is less satisfactory for the flow.

The multirotor helicopter considered is a tandem-rotor helicopter with two equal rotors rotating in opposite directions at the same tip speed. The tandem-rotor aircraft presents the rotor interference problem at its most serious, and it may also be an important type of helicopter for passenger transport in the immediate future. The author's general description of the theory of this type of helicopter covers the topics of longitudinal stability in hovering flight, lateral stability in hovering

flight, longitudinal control in hovering and vertical ascent, longitudinal control in forward flight, performance and trim of a typical tandem rotor helicopter, and longitudinal stability in forward flight.

It is necessary to move the center of gravity of a tandem-rotor-helicopter ahead of the position where best performance is obtained if longitudinal stability in forward flight is to be achieved. This is illustrated by the calculation of the stability of a typical tandem-rotor helicopter for two positions of the center of gravity. It is concluded that it may be possible to provide longitudinal stability only above a certain speed, which might be chosen to be the speed for maximum rate of climb.

Operation Whirlwind—Past, Present, Future

Clarence M. Belinn, President, Los Angeles Airways, Inc.

The author discusses in detail the historical background of Air Mail Route AM-84, Los Angeles, over which Los Angeles Airways, Inc., began operating a scheduled air-mail helicopter service a year and a half ago. A considerable amount of attention is given to the part scheduled helicopter services might play in national defense in times of widespread emergency. The value of helicopters and helicopter services in national defense is related to the economic self-sufficiency of scheduled helicopter operations. As a local transit feeder system, these provide the large metropolitan airports with a terminal service and uncover for the trunk lines a heretofore untapped source of traffic in at least three forms: mail, express, and passengers.

The history and background of the establishment of Route AM-84 is extended, with an account of the difficulties encountered in the early operations when no prior concept or formula was available for guidance in overcoming many technical problems. Specifications for landing sites, airway patterns, and procurement and training of staff and flying personnel had to be worked out. Flight regulations that had been established years ago and were based on fixed-wing concepts of flying had to be considered.

Next treated are the day-to-day problems of communication, navigation, night flying, personnel training, traffic generation, and the design and production of ground and air-borne equipment especially adapted for the operation of a scheduled helicopter service.

Finally, the future of rotary-wing aircraft is projected by examining large transport helicopter specifications, maintenance and operational techniques, legal and regulatory problems, and financial and economic potentials. These observations are supported by information gathered from actual operating experience. Of particular significance is the tremendous increase in mail traffic. For example, 368,350 lbs. of mail were carried in March, 1949, as compared with 60,360 lbs. in October, 1947. This represents an increase of 610.26 per cent. Data on equipment utilization are also presented. One helicopter was modified in the company's shops to allow for 46 per cent greater cubic content; subsequently, this aircraft turned in an average of $7^1/_2$ hours daily utilization over a period of several months.

Aircraft Materials Session, Wednesday Morning, May 25. ***Left to right:*** **A. E. Russell, Chief Designer (Aircraft), Bristol Aeroplane Co. Ltd.; P. Litherland Teed, Deputy Chief of Aeronautical Research and Development, Vickers-Armstrongs Ltd.; Clyde Williams, Director, Battelle Memorial Institute.**

Aircraft Materials

THE QUESTION OF aircraft materials was the common concern of the three lecturers on Wednesday morning. A. E. Russell and P. L. Teed discussed the state of knowledge in Great Britain from the designers' and manufacturers' points of view. Developments on this side of the Atlantic were recounted by Clyde Williams, Director of the Battelle Memorial Institute. Dr. C. C. Furnas, Director of Cornell Aeronautical Laboratory, Inc., introduced the authors and led the discussion.

Aircraft Materials from the Designers' Point of View

A. E. Russell, Chief Designer (Aircraft), Bristol Aeroplane Company Ltd.

A dominating problem in the design of aircraft structures is the stability of panels in compression. Close agreement with experimental results suggests that a theoretical analysis forms the most rational basis for the selection of the materials of construction, both with regard to kind and quality. Important structural advantages will accrue from the use of metal adhesives. Their use will increase the demand for thin sheet and strip. An examination of the statistical variation of dimensions and strength of sheet and extrusions shows that in certain circumstances it is possible to make better use of a material than that allowed by normal specification conditions. Development is needed to reduce the variability of directional properties of materials. The results of fatigue tests on standard specimens may be misleading if used indiscriminately in design. Laboratory work needs correlating to typical structures.

For the purpose of explaining the design procedure followed in the paper, the behavior of a structural box is described, which is made up of sheet reinforced by uniformly spaced stiffeners and supported at intervals by frames. Following an outline of the four types of instability which are likely to develop (skin buckling, local instability, torsional instability, and flexural instability), theoretical and experimental results are presented for Z-section, inverted-Y, rounded hat-section stiffeners with minor intermediates, and plain rounded hat-section stiffeners. Rib structure, selection of materials properties, metal adhesives, sandwich construction, dimensional and strength variability of sheets and extrusions, directionality, and fatigue are treated in the remaining four-fifths of the paper.

A design staff must have both a short- and a long-term plan for the selection and application of materials. Mainly, the short-term plan is built around the problems of existing or immediately projected aircraft, whereas the longer term is less restricted by the politics of the home plant or other parties. The function of long-term research is to find out what is technically best.

Considerable progress has been made toward establishing a theoretical understanding of the relationship between a material's physical characteristics and its behavior under static loading. According to the design needs, a proper choice of material can be made; moreover, the designer can indicate to the materials research worker those qualities that by improvement would yield most beneficial results. For fluctuating loading the position is not so happy.

It is, however, impossible to generalize on the selection of materials; otherwise one could not reconcile the multitude of specifications available. Each aircraft must be treated on its merits, taking into account its size, probable quantity in production, time spent in development, its function as a civil and military type, and so on throughout the whole gamut of design.

The Application of Materials from the Manufacturers' Point of View

P. Litherland Teed, Deputy Chief of Aeronautical Research and Development, Vickers-Armstrongs Ltd.

Because of insistent military and civil demands for improved performance, air-frame and aircraft-engine designers are called upon to make still greater efforts to improve designs. In addition to major demands for decreased drag and increased fuel economy, there is an emphatic call for reduced weight unaccompanied by any reduction in safety. In order to meet this last requirement, the designer's greatest need is to know the basis on which to make his selection from the excess of materials specifications concerned with only a few static mechanical properties. The high flight altitudes of both civil and military aircraft and the long aircraft life demanded by air-line operators give increased significance to two aspects of the materials question: (1) the mechanical properties of materials at stratospheric altitudes and (2) their fatigue and notch fatigue resistance under all conditions of temperatures.

In the introductory part of the paper, the author compares the material requirements of the aircraft industry with those of other industrial fields to show likely trends in materials development and specifications. Many required characteristics of materials are still not known with certainty, and the choice of a material is complicated by the methods of selection and assessment. Part II is a survey of the properties of metallic materials at stratospheric altitudes. The chemistry of metals under stratospheric conditions of reduced atmospheric pressure and water-vapor content is examined, together with the effect of low temperatures on the mechanical properties of tin, zinc die-casting alloys, aluminum alloys, magnesium alloys, and ferritic and austenitic steels.

Part III, which comprises more than two-thirds of the paper, is a review of the present knowledge of fatigue. References to the literature, numerous tables, and diagrams are introduced to illustrate the effect of various stresses and conditions on mechanical characteristics and fatigue phenomena. A brief historical note on the growth of knowledge of the effects of fluctuating loads on structures is followed by an explanation of the physical causes of fatigue failures. The discussion continues with an investigation of work-hardening at stresses below the fatigue limit, the influence of understressing and overstressing, and the forecasting of the length of life of a part subjected to cyclic stresses. Crystal size, grain size, the nature of stresses producing fatigue failure, the complexity of structure of commercial alloys, the relationship of fatigue to ultimate tensile stress, and fatigue tests are then investigated. The final section of the paper is devoted to stresses arising from heat-treatment, the influence of inclusions, surface finish, aluminum-alloy clad sheet, notch effect, screw threads, fatigue of bolts and studs, rolled threads, riveted joints, spot-welds, thermosetting, organic adhesives, shot-peening, cold-rolling nitrogen-hardening, case-hardening, and corrosion fatigue.

Materials in the Aircraft Industry

Clyde Williams, Director, Battelle Memorial Institute

The effective use of materials in the aircraft industry is primarily one of achieving desired results with minimum weight. The ideal aircraft would be one in which every cubic inch of material would, at one time or another, be stressed to its ultimate safe limit by service loads. The designer must have precision knowledge of the loads to be encountered and the stresses resulting therefrom. The materials engineer must provide sufficient information on the properties of materials so that the designer may choose the one best suited for his purpose.

Mechanical property data on material should be available for the entire temperature range in which each is applicable. In view of the importance of elastic and

plastic stability, compression stress-strain data are particularly important.

For the common aluminum alloys, most of the data required for designing structures to operate near room temperature are available. Some additional low-temperature data would be desirable. There are few elevated-temperature stress-strain curves in compression and practically no data on creep in compression. There are data on steady-state creep in tension; however, there are not enough data on initial stages of creep. While there is a considerable body of fatigue data at room temperature, even here there are not enough data to allow comprehensive analysis of the effect of stress concentration factors or of fatigue damage. There are very few high-temperature fatigue data.

The extent of data on magnesium alloys is roughly the same as for aluminum alloys. While the low density of magnesium alloys makes them attractive for aircraft use, more alloy development is required in order to overcome other shortcomings.

The problem of obtaining sufficient strength information on steels is tremendously complicated by the wide variety of properties that can be obtained in a single steel by means of heat-treatment. The data on steels, just as on aluminum and magnesium alloys, are not sufficient for high-temperature design. Because of the low-temperature brittleness often found in ferritic steels, low-temperature data are more important than for aluminum alloys.

Titanium and titanium alloys are potentially attractive not only because of their high strength-weight ratios but also for their good elevated-temperature properties and corrosion resistance. For elevated-temperature use, they fill the gap between aluminum or magnesium alloys and steel.

Ceramics have attractive elastic properties and are generally low in density; however, many strength problems must be solved before they can be used for structural purposes.

A final factor having an important effect on choice of materials is availability. It is important for designers to find ways of effectively using materials that will be available in ample supply in event of an emergency.

Loening Reviews U.S. Personal Plane Situation

In an analysis of the deficiencies of today's personal aircraft, Grover Loening called upon manufacturers to produce a "really versatile aircraft that can hover, land vertically, take off, and fly 200 miles an hour or more." Loening spoke on Wednesday, May 25, at the luncheon held in the Hotel Astor for the R.Ae.S. delegates attending the Conference. New customers, he said, would be greatly interested in an aircraft that could be operated "with much greater scope as to where one could go and much greater assurance of regularity, and less noise," and in an aircraft that would be "easier to fly and safer to land in unprepared close-in areas under more difficult wind and weather conditions."

In June, 1948, Loening made a similar plea for intensified research into personal airplane problems when he addressed I.A.S. Members in Dayton as Panel Chairman of the I.A.S. Fifth Annual Personal Plane Meeting, the first I.A.S. "Meeting on Wings." The N.A.C.A. has since learned more about personal-plane problems and the attitudes of owners and prospective users, and this added knowledge was reflected in his suggestions for improving personal planes by utilizing research results that are already well known.

Grover Loening's 40 years of intimate association with aviation and his recent experience as Consultant to the N.A.C.A., which is currently making a survey to determine what must be done to perfect personal planes and to extend their use, enabled him to speak with authority on means of enlarging the market potential of personal aircraft. His long experience in industry and Government includes such positions as General Manager of The Wright Company, Chief Aeronautical Engineer of the U.S. Army Signal Corps in 1914 and 1915, Consulting Engineer to the U.S. Aircraft Production Board in 1916, and President of his own enterprises from 1917 to 1938. He was Aeronautical Adviser to the U.S. Maritime Commission in 1937 and 1938 and more recently served as Consultant on Aircraft to the War Production Board during World War II from 1942 to 1945. For his accomplishments in this post, he was awarded the Medal for Merit by President Harry S Truman in January, 1948.

The complete text of Mr. Loening's address is printed elsewhere in this issue.

Aircraft Structures

Structural efficiency at high speeds, longer aircraft life, greater safety, and improved performance were the objectives of the investigations described Wednesday afternoon. A. Flax, Assistant Head, Aero-Mechanics Department, Cornell Aeronautical Laboratory, Inc., was the first speaker. He was followed by H. A. Wills, of the Division of Aeronautics, Australian Council for Scientific and Industrial Research, and G. G. Green, Chief of Structures, Consolidated Vultee Aircraft Corporation. Joseph S. Newell, Professor of Aeronautical Structural Engineering, Massachusetts Institute of Technology, was Chairman.

Aeroelastic Problems at Supersonic Speeds

A. Flax, Assistant Head, Aero-Mechanics Department, Cornell Aeronautical Laboratory, Inc.

Some of the important problems involving the coupling of aerodynamic and elastic effects at supersonic speed, in particular insofar as they differ from those encountered in low-speed aircraft, are treated. These new problems are traceable to two major causes: first, the

Afternoon Session, Wednesday, May 25. *Left to right:* Joseph S. Newell, Professor of Aeronautical Structural Engineering, M.I.T., Chairman; A. Flax, Assistant Head, Aero-Mechanics Department, Cornell Aeronautical Laboratory, Inc.; H. A. Wills, Division of Aeronautics, Australian Council for Scientific and Industrial Research; G. G. Green, Chief of Structures, Consolidated Vultee Aircraft Corporation.

differences between supersonic flow and subsonic flow; and, second, the differences in configuration between subsonic aircraft and their power plants.

First, the problem of supersonic flutter is considered, particularly the problem of single degree of freedom flutter at low supersonic Mach Numbers of a wing in torsion or of a control surface. The influence of damping on this mode of flutter is demonstrated to be of importance in certain cases. The nature of the single degree of freedom flutter branch when another degree of freedom is present is illustrated. The flutter problem for a swept wing with particular reference to the choice of appropriate aerodynamic coefficients is examined.

The problems of static aeroelasticity are dealt with on the basis of second order aerodynamic theory. It is shown that second order effects may cause considerable differences between these results and the results of a linearized theory analysis for wing sections of moderate thickness. Aeroelastic amplification factors on the basis of second order theory are derived. The influence of three-dimensional aerodynamic effects on divergence and related problems for straight wings is evaluated.

The class of static aeroelastic problems in which aerodynamic forces are proportional to the local slope of a lifting surface is considered. Among these problems are the familiar swept-wing problems and the problem of chordwise divergence of a thin supersonic airfoil first treated by Biot. The differential equations for such problems are not similar to the dynamical equations for wing torsional vibration, as are those encountered in the usual aeroelastic theory of straight wings. In particular, the validity of energy methods (Rayleigh-Ritz) in such problems is investigated. Certain modifications of usual energy methods are shown to be appropriate. The results are applied to the approximate treatment of the influence of swept wing and tail elasticity on static longitudinal stability and on lateral control effectiveness. The use of matrix iteration procedures for determination of the loading on a flexible sweptback wing is reviewed, and a procedure is given for cases where the usual process does not lead to convergent results. The influence of three-dimensional aerodynamic effects on swept-wing bending divergence is evaluated approximately.

Static aeroelastic effects due to tip tanks or tip jet propulsion units, often proposed for supersonic configurations, are shown to be significant not only for divergence but also for longitudinal static stability at speeds below the divergence speed. The effect on longitudinal stability is shown to grow worse with flight Mach Number even for a fixed aeroelastic amplification factor.

The Life of Aircraft Structures

H. A. Wills, Division of Aeronautics, Council for Scientific and Industrial Research, Australia

An endeavor has been made to survey the problem of life estimation as it concerns aircraft structures and to discuss briefly the salient factors involved. The chief trends leading to a greater probability of fatigue are: (a) the steady increase in working stresses in wings because of design refinement and reduction in load factor; (b) the general increase in cruising speeds and the corresponding increase in the number and severity of the impulsive loads due to gusts; (c) the increase in size of aircraft with reduction of the resonant frequency of the wing structure to something approaching the gust frequency; and (d) the development of new materials of high ultimate strength which do not all possess proportionally high endurance limits and are generally more notch sensitive than the lower-strength materials.

The loads applied to aircraft structures in flight are next considered, firstly, the steady maneuvering and gust loads used in design and the factors affecting the latter such as wing loading, aspect ratio, and Mach Number; and secondly, the fluctuating loads arising from the action of sequences of gusts on the resilient structure. Typical load-frequency distributions obtained from V-g recorder data are given.

The resistance of the structure to fluctuating loads is then discussed, and mention is made of laboratory experiments conducted to investigate the fatigue resistance of components or to determine and correct the cause of failure in service. Some preliminary results obtained from tests on a series of metal wings at different load ranges are compared with similar tests on riveted joints. The fatigue resistance of the complete structure was appreciably less than that of the joints, particularly in the region of 10^3 to 10^4 cycles to failure. A method of obtaining load-endurance data for any load range ratio is suggested, and a procedure, simplified for purposes of illustration, for estimating the time in flying hours to failure using these data and the typical load-frequency curve is described.

Although V-g recorders have provided useful data, the changing character of aircraft structures due to increases in size and speed demands data of a more

detailed nature. The direct measurement of strain fluctuations by a statistical counter is regarded as an essential to further progress in life estimation. More must be known about the response of structures to fluctuating loads, particularly loads that do not fluctuate about a zero value. From the calculation given and others of a more detailed nature, it appears that load fluctuations of small magnitude of the order of L.F. 0.5 and less do not contribute significantly to the fatigue of the structure.

It is concluded that, although the factors on which the life of an aircraft structure depend are so numerous, complex, and interrelated that we may never know sufficient about them to make precise estimates of safe operating life, a thorough study of them will undoubtedly lead to sounder and more efficient design that will be reflected in fewer failures in service and greater safety.

American Structural Design Trends

G. G. Green, Chief of Structures, Consolidated Vultee Aircraft Corporation

This paper reports on a survey of the trends in aircraft structural material usage and in structural arrangement and presents an investigation of some effects of the trends in aircraft configuration, loading, and speed on wing structure.

High-strength aluminum alloy is observed not only to be maintaining its position as the major structural material but also to be invading fields previously considered the province of steel. High temperatures resulting from supersonic flight appear to be the only important threat to the supremacy of aluminum alloy. The use of 75S-T becomes doubtful at temperatures above 200° to 250° F. The stainless steels and Inconel X are among the best choices at 300° F. and higher. Titanium, which is relatively new as a structural material and is not yet produced in commercial quantities but is potentially plentiful, is indicated to show great promise, particularly in the range of temperatures to be encountered by aircraft flying at supersonic speeds.

The successful use of much magnesium alloy in the structure of several current aircraft is noted as an indication of probable wider use of this material in applications not involving high temperatures.

A brief examination of fuselage and control-surface structures discloses little novelty. The general replacement of metal for the fabric covering of the movable control surfaces has brought about renewed interest in integrally stiffened sheet.

Wing structural arrangements are shown to be strongly affected by the requirement for torsional stiffness sufficient to provide roll control effectiveness (the avoidance of aileron reversal) and by the intensity of beam loading. The former varies directly with the cube of span and with speed squared and is also affected adversely by increasing Mach Number and sweepback. The difficulty of meeting the requirement is approximately inverse to the wing thickness ratio. Loading intensity varies directly with wing loading, span, aspect ratio, and load factor and inversely with thickness ratio and influences the choice of structural arrangement through its effect on the amount of material the designer has to work with.

Several wings selected to illustrate the effects of these two factors are examined in detail, and the merits of several types of construction are considered. Thick wings for aircraft of moderate speed are influenced only slightly by the stiffness criteria. On thinner wings flying at higher speeds, the stiffness criteria have a progressively larger effect, with the frequent result that the structural efficiency suffers. It is shown that the existing trends in aircraft configuration and performance lead finally to the situation that stiffness criteria will override strength criteria and become the major-structural design consideration.

The design aspects of delta wings are discussed briefly, and it is shown that the delta type is a logical solution of the problem of aircraft with performance extending into the supersonic range.

Auxiliary Power and Control Boosting

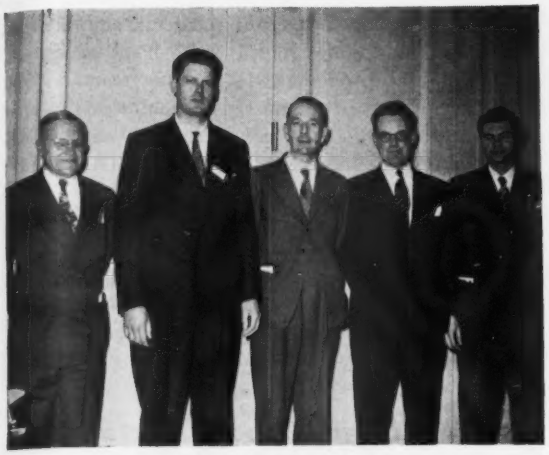
WEDNESDAY WAS a busy day for the conferees. In addition to the regular morning and afternoon sessions, the Program Committee had scheduled an evening session at which four papers were presented. Under the chairmanship of Charles H. Colvin, Vice-President of G. M. Giannini & Co., Inc., H. G. Conway, R. H. Woodall, and H. R. Haerle debated the relative merits of hydraulic, electrical, and pneumatic systems from the British point of view. The evening program concluded with a discussion of aerodynamically boosted surface controls by O. R. Dunn.

The Relative Merits of Auxiliary Power Systems—The Hydraulic Aspect

H. G. Conway, Technical Director, British Messier Ltd.

Claims and counterclaims on behalf of the various types of aircraft auxiliary systems are numerous, and the mixture of systems is often the best solution. One fact, however, stands out before all others: Hydraulic actuation is used on at least 95 per cent of the world's aircraft by type and probably on 99 per cent by numbers.

If an aircraft of the Constellation type is assumed, a pneumatic system has the unacceptable features of long inflation times and the extremely high weight of bottles and the air itself, and electric actuation again introduces prohibitive weight and complication. In England, hydraulic pressure has risen more or less geometrically from 750 to 3,000–4,000 lbs. per sq.in., whereas pneumatic pressures have been developed gradually only to 1,500 lbs. per sq.in., and a sudden jump in pressure from 1,500 to 3,000 lbs. per sq.in. goes



Wednesday Evening, May 25, Session on Auxiliary Systems and Aerodynamically Boosted Surface Controls. *Left to right:* Charles H. Colvin, Vice-President, G. M. Giannini & Co., Inc., Chairman; H. G. Conway, Technical Director, British Messier Ltd.; R. H. Woodall, Chief Engineer, Rotax Ltd.; H. R. Haerle, Chief Technician, The Hymatic Engineering Co. Ltd.; Orville R. Dunn, Stability and Control Engineer, Santa Monica Engineering Div., Douglas Aircraft Co., Inc.

against the principles of common-sense and good engineering.

The comparison of two theoretical elementary hydraulic and pneumatic systems leads to the conclusions that pneumatics will weigh at least the same; air-bottle weight is the main difficulty, since production spherical bottles have a weight at least twice the theoretical; the weight of air is greater than generally realized; and, with a low expansion ratio, what is gained in bottle volume will be lost in extra weight in cylinders and piping. Pneumatics are inferior to hydraulic systems in lubrication efficiency, corrosion resistance, low-temperature performance, the ability to provide locking of cylinders, the tracing of leaks, the damping of rapid motion in landing gear and other components, flow control and division, operation of motors explosion risks, and off-loading to remove pressure from the system during long operational flights. Electric equipment suffers by comparison with hydraulic equipment in weight, emergency actuation, and some minor points.

The following are some of the problems of hydraulic systems and solutions: Fire risk is eliminated by the use of nonflammable fluids, but the hazard of flammable fluids can be mitigated by optimum location of lines and components and by adequate drainage should leaks occur; messy leakage can be overcome by proper location of pipes and remote control instead of long lines; dirt sensitivity and gland wear can be reduced by thorough filtering and the use of O-seals, preferably of the European type; appreciable weight of fluid and piping is reduced by using higher pressures and lighter cylinders, fluid and piping; reversibility may be a disadvantage or an advantage, according to the application; thermal expansion of the trapped fluid is serious, but special thermal relief valves have been evolved in England, though their design was most difficult. A proper appreciation of these defects will strengthen the already strong position of hydraulic actuation and keep the alternative pneumatic and electric systems in their proper place as specialized alternatives suitable for particular duties in particular cases.

The Relative Merits of Auxiliary Power Systems—The Electrical Aspect

R. H. Woodall, Chief Engineer, Rotax Ltd.

Auxiliary power may be defined as representing all power used on an aircraft other than that required for the propulsion of the craft. It is the object of this paper to outline the various methods of producing this power and to show the merits of one method of generating, distributing, and utilizing the power—the electrical method. The author summarizes the existing regulations for the approval of aircraft electrical installations and equipment in Great Britain, analyzes the electrical load requirements of modern aircraft, and indicates the particular ancillary equipment for which a choice of service exists.

Two groups of services are distinguished: those for which electricity is essential, and those for which a choice of auxiliary systems exists. Electricity is essential for lighting, starting of engines, radio and radar, galley equipment, propeller deicing and anti-icing, fuel-pump motors, gaging, military equipment, and other devices. These services where electricity is an essential represent practically all the continuous power loads on present aircraft. In the following the load is always an intermittent one only, and a choice of system exists: brake operation, wing deicing, propeller-pitch control and feathering, landing-gear actuation, flap actuation, engine control, boosting and powering of flying controls, and instruments.

Various methods of producing auxiliary power, present types of electrical generating equipment, and future aircraft electrical installations are then discussed. After a survey of the present and future use of electrical actuators in place of hydraulic or pneumatic units, the paper closes by pointing out the merits of a system that is mainly electrical.

The power-weight ratio of electric generating units will increase as the continuous-load requirements increase. Hydraulic and pneumatic pumps driven by electric motors aid in avoiding line loss and excessive weight of pipes, in lessening the vulnerability of systems in military aircraft, and in avoiding the continuous running of pumps required for intermittent duties. In comparing electrohydraulics and electrics, there is little choice from the point of view of weight when considering large actuators. However, the electrical actuator is somewhat more efficient. Electrical actuators are easily disconnected by the removal of a plug from a socket. It is easier to design electrical systems for higher voltages and generators and motors for higher speed than it is to design and build hydraulic pumps for high speed and high pressure. The desirability of

maximum electrical utilization is obvious in that all ancillary equipment except brakes can be thus operated. Electrical equipment is easier to service, is clean, is easily controllable, and is designed to operate for long periods without attention. Aircraft designers are realizing the merits of electrical actuation, and many civil and military British aircraft will change over to electrics for many ancillary services.

The Relative Merits of Auxiliary Power Systems—The Pneumatic Aspect

H. R. Haerle, Chief Technician, The Hymatic Engineering Company Ltd.

An aircraft auxilary power system that approaches the ideal is one that covers the largest range of services with the least weight and the greatest degree of safety and reliability. Some of the advantages of compressed air are the universal availability of air; the adaptability of compressed air to a wide range of services; and its safety, since there is no inflammable fluid and, even where methanol injection has been employed to prevent freezing of moisture in the system, no cases of fire following leakage are known. Other merits are: greater possibilities for light weight, reliable energy storage; fewer, simpler, and less damageable parts; lighter working fluid, pipes, rams and storage bottles; suitability for rotary, linear, or inflation purposes; rapidity of operation; and cleanliness. Compressed-air systems have limitations caused by compressibility of air, low overall efficiency, leak sensitivity, and freezing in medium-pressure systems. Compressibility effects can be satisfactorily minimized by providing simple damping devices and by utilizing the damping effect of piston sealing rings, as in a typical multiposition wing-flap ram; furthermore, pressure surges are considerably smaller than they are in hydraulic systems.

Although the inefficiency of pneumatic systems for transmitting continuous power is more marked with increase in pressure, the difficulty may be avoided by using high pressures for intermittent output and low pressures for continuous output. Leaks in the system have usually had no serious consequences. Freezing troubles have been eliminated in medium-pressure systems by injecting methanol vapor and in high-pressure systems by removing about 99.5 per cent of the condensed water vapor in a simple, mechanical manner before the compressed air enters the system. Progress in the past 15 years and typical installations on current aircraft using pressures up to 1,000 lbs. per sq.in. are reviewed to illustrate the savings that have been effected. Information based on current experimental work is used to point out what can be done in the future and how the number of applications of pneumatic auxiliary systems in aircraft can be increased by designing and utilizing pressures up to 3,000 lbs. per sq.in. Normally aspirated compressors, boosted compressor systems, regenerative systems, direct control, actuation, and relay-operated systems all have their advantages in particular applications, and they offer the designer a wide choice of systems. Pneumatics are well suited for emergency services, since they are easily put into operation, are simple and light, and have shown complete reliability. Compressed-air equipment can be integrated with other systems, such as electric compressor drives, electrical synchronizing devices, and hydraulic shock absorbers or dampers. In installation, considerable latitude is permissible in the disposition of components. In servicing, they can be maintained easily by semi-skilled labor, are accessible, and are comparatively immune from injury due to mishandling.

Aerodynamically Boosted Surface Controls and Their Application to the DC-6 Transport

Orville R. Dunn, Stability and Control Engineer, Santa Monica Engineering Division, Douglas Aircraft Company, Inc.

Aerodynamic boost is defined as any device that assists the pilot in moving the various control surfaces and depends for its operation directly on the energy of the air stream around the control surface. Such devices include aerodynamic nose overhang and internal pressure balances on the main surface and all types of tab control systems.

The most significant result obtained from a general analysis is the fact that all aerodynamic boost systems are of but one general type governed by a single set of equations. Knowledge of the details of the mechanical linkage is unnecessary. Only three basic linkage parameters are required to define the system.

The physical significance of each of the various system parameters is examined, and the effects of these parameters on the pilot force characteristics are exemplified with the DC-6 transport as a basis for comparison. Since this airplane incorporates both aerodynamic nose balance and tab boost on all three control surfaces, it serves as a good illustration of the successful application of this general type of boost system to a modern high-speed commercial transport.

The equations developed for use in analytical design analyses assume that the aerodynamic coefficients are linear functions of the angle of attack and surface deflections and that the mechanical linkage characteristics are linear functions of the main surface, tab, and cockpit element motions. Normal linkage configurations may usually be assumed linear, but aerodynamic chacracteristics cannot always be so represented. Examination of typical hinge-moment data shows that such data usually can be linearized with sufficient accuracy for most of the necessary design analyses; the need for graphic solutions is therefore reduced to a minimum. Since certain types of surfaces, notably the Frise aileron, have characteristics that cannot be made linear, a simple graphic process is presented.

Study of the overall merit of aerodynamic boost systems, their advantages and limitations, their cost and efficiency, and their performance based upon experience leads finally to the general conclusions summarizing their status: (1) aerodynamic boost should be capable of producing satisfactory pilot forces on present transport aircraft types weighing up to several million pounds; (2) aerodynamic boost should be capable of producing satisfactory pilot forces on high-speed aircraft up to speeds corresponding to a Mach Number of approximately 0.95; and (3) aerodynamic boost may be capable of producing satisfactory forces at Mach Numbers above 0.95, although the scarcity of data available for the high transonic and supersonic speed ranges precludes any accurate prediction of its capabilities at these speeds.

Technical Session, Thursday Morning, May 26. *Left to right:* Francis H. Clauser, Chairman, Aeronautics Department, The Johns Hopkins University, Chairman of the Session; Walter G. Vincenti, Ames Aeronautical Laboratory, N.A.C.A.; E. G. Broadbent, Structures Department, Royal Aircraft Establishment; Floyd L. Thompson, Chief of Research, Langley Aeronautical Laboratory, N.A.C.A.

High-Speed Flight

Dr. Francis H. Clauser, Chairman of the Aeronautical Department of The Johns Hopkins University, directed the meeting on Thursday morning. The three speakers, Walter Vincenti, E. G. Broadbent, and Floyd L. Thompson, proposed their solutions to the problems arising from the flight of airplanes and missiles in the transonic and supersonic speed ranges. Mr. Vincenti compared the results of theoretical investigations of wings for supersonic flight with the results obtained experimentally, and Mr. Broadbent considered the important effects that the bodily degrees of freedom may have on aircraft wing flutter. Mr. Thompson described the methods and techniques developed by the N.A.C.A. for conducting research at transonic and supersonic speeds with free-falling and rocket-propelled models.

Comparison Between Theory and Experiment for Wings at Supersonic Speeds

Walter G. Vincenti, Ames Aeronautical Laboratory, N.A.C.A.

With the assumption of a perfect, inviscid gas, the characteristics of airfoil sections in two-dimensional flow can be calculated to varying degrees of accuracy for a wide range of profiles and angles of attack. To obtain results for complete, three-dimensional wings, however, it is necessary to linearize the mathematical problem at the outset by the additional assumption of thin wings and small angles of attack.

In the two-dimensional case, it is possible to distinguish clearly between the effects of viscosity and the effects of the quantities neglected in the linear approximation. This is illustrated by comparing the results of theoretical calculations with pressure-distribution data from the two-dimensional tests of Ferri.

In the three-dimensional case, because of both the wide practical range of wing shapes and the mathematical restriction to linear methods, the comparison between theory and experiment is more complex. This is shown by the results of a recent N.A.C.A. study. The results of the study show, in most cases, excellent agreement between theory and experiment with regard to lift-curve slope. The agreement with regard to moment-curve slope is generally less satisfactory. For unswept wings, the differences in this respect can be explained by reference to the previous discussion of two-dimensional phenomena. For swept wings, the discrepancy is difficult to reconcile on the basis of present knowledge.

For wings of a given chordwise thickness distribution, the influence of variation in plan form upon the measured value of the minimum drag is in qualitative accord with theory. The increase in minimum drag for wings swept in the vicinity of the Mach cone is, however, less than predicted. For triangular wings of double-wedge section, the effect of changing the chordwise position of maximum thickness for a fixed plan form and Mach Number was found to be considerably different from that indicated by theory, forward movement of the maximum thickness failing to produce the decrease in minimum drag which inviscid theory predicts. Boundary-layer studies by the liquid-film method show that this result is due to an accompanying increase in the extent of turbulent boundary-layer flow. These results have general implications with regard to the reduction of drag through the use of sweep.

For all cases in which the leading edge of the wing was outside the Mach cone (i.e., "supersonic" edge), the measured rise in the curve of drag versus lift was found to be in reasonable agreement with theory. The results of the study were not conclusive with regard to the conditions required for the attainment of the forward force that theory predicts on the leading edge when the edge is within the Mach cone (i.e., "subsonic" edge). On triangular wings of this type,

however, forward displacement of the maximum thickness and subsequent rounding of the leading edge did have a measurably beneficial effect in reducing the drag due to lift and increasing the maximum lift-drag ratio.

Some Considerations of the Flutter Problems of High-Speed Aircraft

E. G. Broadbent, Structures Department, Royal Aircraft Establishment

It is the purpose of this paper to draw attention to the important effects on aircraft wing flutter which the bodily degrees of freedom may have. A general review of the flutter problems of high-speed aircraft precedes an examination of the sweptback wing encastré. A résumé of theoretical work on sweptback wings summarizes Minhinnick's method of overcoming the difficulty presented by the effect of the change in camber of the aerodynamic section as the wing bends. Minhinnick considers the downwash at a point and compares the results with those for an unswept wing. His results were the more readily adaptable to existing methods of calculation and were therefore adopted in a number of subsequent calculations. It has been found that results agreeing closely with those of Minhinnick's method can be obtained by factoring all the standard aerodynamic derivations taken in the line of flight by the cosine of the angle of sweepback ($\cos \epsilon$). This approximate $\cos \epsilon$ rule is applied to a sweptback wing to achieve a physical picture of the general effect of sweepback on the simplest form of wing flutter, and experimental results are examined and compared with theoretical results.

Theoretical results for the free aircraft with sweptback wings are followed by a discussion of flutter involving wing bending, the normal mode, and types of flutter involving wing torsion. Results of the detailed theoretical analysis of a hypothetical swept-wing aircraft show that the problems of coupled ("classical") symmetric flutter of the new wing plan forms for high-speed aircraft are more serious and complex than for conventional plan forms, because of the effect of the aircraft bodily freedoms. These freedoms can produce new forms of flutter that involve a body-freedom mode and an elastic mode in place of two elastic modes. If the one elastic mode is primarily flexural, then the flexural stiffness of the wing becomes an important factor in flutter prevention—the reverse of the present picture in which the torsional stiffness criterion is the only one considered. A criterion is proposed for deciding the dangerous type of fundamental normal mode to be considered in flutter calculations. Experiments at the Royal Aircraft Establishment with the body free are still in the early stages, but results obtained thus far emphasize the importance of the body freedoms. For the immediate future, a hopeful line of investigation seems to be the measurement of critical speeds on flight models. These models may be either dropped from altitude or propelled by rocket power. Small models could also be carried on high-speed parent aircraft. A brief description is given of the work proposed to complete the attack on the problems and to provide for the prevention of flutter in high-speed aircraft. Whatever the method of attack, ground resonance tests of the completed aircraft will play an important part, and any improvements that can be made in the measuring or vibrating apparatus will be extremely valuable.

Flight Research at Transonic and Supersonic Speeds with Free-Falling and Rocket Propelled Models

Floyd L. Thompson, Chief of Research, Langley Aeronautical Laboratory, N.A.C.A.

During the past few years it has been necessary for aeronautical research workers to exert a good portion of their effort to develop the means for conducting research in the high-speed range. The transonic range particularly has presented an acute problem because of the choking phenomena in wind tunnels. The purpose of this paper is to discuss techniques developed by the National Advisory Committee for Aeronautics during the past several years for conducting high-speed research in free flight with models propelled by gravity and rockets. These methods yield continuous data through the transonic range, thereby permitting the research worker to obtain the basic aerodynamic data required for aircraft and missile design. A wide variety of aerodynamic investigations in the transonic and supersonic range have been carried out by these methods.

In investigations with free-falling bodies, particular emphasis has been placed on the determination of the drag of bodies and bodies with wings at zero lift. With rocket-powered models, considerable emphasis has been placed on problems of stability and control as well as on drag, and procedures have been developed to permit a rather thorough investigation of the longitudinal stability and control characteristics of a given configuration in a single test. Investigations of flutter have been made with both techniques. Results are shown for various applications of the techniques employed with particular emphasis on the problem of drag and control effectiveness in the transonic range.

From the free-fall tests with bodies of fineness ratio varying from 6 to 12, it is shown that the body of fineness ratio 12 has by far the least drag beyond a Mach Number of 1.0 but that, because of its greater length, it is at a disadvantage in the subsonic range. The advantages of the finer nose shape beyond a Mach Number of 1.0 are also indicated. In experiments with wings in test of free-fall models, the marked advantages of sweepback in reducing the drag are shown. In experiments with rocket-powered models, the relative advantages of sweepback and aspect ratio in reducing the drag are shown. In general, the effects of sweep far over-shadow the effects of aspect ratio as a means of obtaining low drag for speeds such that the sweepback is sufficient to place the wing behind the Mach cone.

Capt. J. Laurence Pritchard, Secretary of the Royal Aeronautical Society, Guest Speaker at the Luncheon on Thursday, May 26.

Results of studies of control effectiveness with rocket-powered models again illustrate the beneficial effects of sweepback in surmounting the problems of the transonic range. Both methods have been useful in providing basic design information and for investigating the behavior of airplanes intended for flight in the critical transonic range.

R.Ae.S. Secretary Recalls I.A.S. Founding

AT THE THIRD AND last of the Conference Luncheons, Capt. J. Laurence Pritchard touched on some of his experiences as Secretary of the Royal Aeronautical Society, a position he has held for over 25 years. His amusing anecdotes recalled some of the visits and correspondence that led to the founding of the I.A.S. in 1932. He also thanked Harry Guggenheim for the considerable support he gave to the R.Ae.S. in 1926 and in subsequent years.

Aircraft Efficiency and Operating Problems

THE LAST TECHNICAL SESSION of the Conference started with a paper by D. Keith-Lucas on a question that has often been the subject of controversy, "Is the flying boat superior to the large landplane?" Mr. Keith-Lucas, who is Chief Designer of Short Brothers and Harland Ltd., took the affirmative. Closely related to this first paper was G. S. Schairer's discussion of the aerodynamic efficiencies of large landplanes. The third and fourth papers reflected the opinions of air-line operators on two important topics. Christopher Dykes, of British Overseas Airways, surveyed the problems likely to arise in operating future civil transports, especially those with gas-turbine power plants. Warren Alberts, of United Air Lines, Inc., spoke on the utilization and maintenance of transport aircraft. The Chairman of this last meeting was William Littlewood, Vice-President—Engineering, American Airlines System.

The Relative Efficiencies of Large Landplanes and Flying Boats

D. Keith-Lucas, Chief Designer, Short Brothers and Harland Ltd.

From a detailed examination of the relationships between the size and structure weight of land animals, aquatic animals, land vehicles, ships, and aircraft, it is shown that simple structures such as under-carriages are influenced by the square-cube law sooner than hulls or floats. Flying boats are therefore favored over landplanes for large sizes.

Three dynamically similar landplanes and equivalent flying boats are projected which are powered by the same engines, have the same range, and carry the same pay load. The flying boat is lighter than the landplane at weights greater than 100,000 lbs. and faster at extremely high weights. The landplane and the flying boat will have the same speed if they are large enough; this point of equal speed occurs somewhere between 250,000 and 500,000 lbs. gross weight. A definite figure for this point cannot be established, since the convergence of flying-boat performance to that of the landplane is so gradual that the point of intersection may be changed by some 250,000 lbs. if the estimates of structure weight are out by only 1 per cent. For practical purposes, the difference in performance between the flying boat and the landplane is extremely small at weights greater than about 250,000 lbs. The availability of bases and the distance to alternate landing places overshadow the flying efficiency.

Final Session Thursday Afternoon, May 26. *Left to right:* William Littlewood, Vice-President—Engineering, American Airlines System, Chairman; D. Keith-Lucas, Chief Designer, Short Brothers and Harland Ltd.; G. S. Schairer, Staff Engineer, Boeing Airplane Co.; Christopher Dykes, Assistant Technical Development Director (Engineering), British Overseas Airways; Warren Alberts, Special Assistant to the Vice-President—Operations, United Air Lines, Inc.

These conclusions are valid whatever the range or speed of operation and whether propellers or jet engines are used. Large aircraft of such sizes are necessary to achieve much increase in traffic volume at air terminals. Large size also brings increased efficiency in terms of pay load and/or speed. Future safety requirements will demand longer runways and alternate airports, which can be provided only at an enormous capital expenditure that even military necessity might not justify. Reduction of the landplane's wing loading is a solution, but it would make the landplane slower than the flying boat. Thus, it appears that the large flying boat will be superior to the landplane for economic reasons.

Flying boats are safer over long water routes and in the event of a forced landing on land and do not suffer from the potential unreliability of an undercarriage. The large flying boat is superior in the three things that pertain to the overall efficiency of an air line: economics, safety, and reliability. The landplane is the more efficient only in the smaller sizes and only if by "efficiency" is meant its aerodynamic and structural efficiency as a flying machine. The greater the size, the greater is the advantage of the flying boat, until, on economic grounds, particularly in connection with provision of airports, it becomes impossible for the landplane to compete.

Aerodynamic Efficiencies of Large Landplanes

G. S. Schairer, Staff Engineer, Boeing Airplane Company

This paper attempts to bring out some of the important factors that determine the value of the airplane as a transportation vehicle and to examine the probable trends of the next few years. The factors that must be determined to evaluate any particular airplane are pay load, range with pay load, speed, and the cost of carrying the pay load over a specified range. Only three principal variables are discussed: power-plant type, Mach Number, and altitude. Other design items, such as size, aspect ratio, design criteria, and airport limitations, are not considered, since their effects are more generally understood. The Breguet range formula, which relates airplane range to airplane weights, aerodynamic cleanness, and power-plant performance, is the principal tool to be used in making the correlations between airplane physical characteristics and airplane operational characteristics. The familiar range-pay load and range-speed curves are critically examined to show the relative importance of various design variables.

The propulsive efficiency of propellers and jets are reviewed. The specific fuel consumption of reciprocating and turbine-type power plants are compared. The resulting fuel utilization efficiencies of the various power-plant types are examined, as well as the power altitude characteristics. The overall influence of these variables upon specific power-plant weight are then investigated.

The principal factors determining the aerodynamic relationships of the airplane are then explored, and the influence of design variables upon lift-drag ratios is then pointed out. The influence of Mach Number on drag is examined. Airplane weights as influenced by Mach Number and power-plant type are shown to have a material influence on the final results with marked superiority of turbojet power plants from an airplane weight standpoint at high speeds. Power-plant and airplane factors are then combined to show their mutual influences and variations at their optimum values for airplane range. A marked superiority of the tuboprop is found at low Mach Numbers and of the turbojet at high Mach Numbers. A crossover point between these two types is found in the high subsonic speed range.

Critical examination of the influence of altitude shows that increasing airplane design altitudes reduces range but that for turbine-type power plants large range penalties are incurred by flying below the design altitude. It is indicated that in many cases airplanes with turbojet and turboprop power plants will be operated close to their buffeting limits and that adequate means to permit safely reducing the buffeting speed margin must be developed. The resulting desire to fly at maximum altitude and speed involves a conflict with present design regulations which must be resolved before the construction of commercial jet transports.

I.A.S. to Publish Conference Proceedings

The forthcoming *Proceedings of the I.A.S.-R.Ae.S. Second International Conference* will contain the texts, with the accompanying diagrams and photographs, of all the twenty-three papers presented at the 3-day Technical Sessions in New York. In addition to these, it will contain a carefully edited transcript of the discussions recorded at the meetings. Comments submitted after the meeting and the replies of the authors will also be included. The book is expected to be over 700 pages in length and will be bound in cloth. The papers are not being published elsewhere, and, consequently, the *Proceedings* will be the only authoritative source for the full record of the Conference. The edition will be limited, and those wishing to purchase copies should place their orders as soon as possible. Further information and an order coupon will be found on page 47 of this issue.

Operating Factors Affecting the Design of Future Civil Transport Aircraft

Christopher Dykes, Asst. Technical Development Director (Engineering), British Overseas Airways

A general survey is made of problems likely to arise in operating future civil transports, particularly those with gas turbines. Much of the paper refers to the requirements of a major international scheduled air line operating outside the United States. The relation of cruising speed to timetables is discussed for short and long routes, both single and multistage. As a general rule, it is much harder to achieve high utilization on high-speed aircraft. Improvements must be made in factors under the control of the air-line operator, such as transportation between the city center and the airport and baggage loading and checking and in customs examinations and visa formalities.

A new method of relating standards of passenger accommodation to comfort is illustrated by application to the selection of the optimum layout. Factors representing weight, cabin volume, floor area, etc., per passenger are plotted against various functions of the trip; the most convenient variable appears to be the trip time per stage. A short résumé of high-altitude wind, ambient air temperature, and humidity information is used to forecast possible limitations, especially in relation to temperature, which is shown to have a major effect on gas-turbine economics by affecting specific range. Various traffic- and airport-control factors are discussed with examples; mention is made of a new index intended to demonstrate the effect on runway-bearing capacity of aircraft with single and multiple wheels.

Cruise-control procedures are exhaustively discussed and compared for piston and turbine-engined aircraft, with particular reference to a new type of air-mile-per-pound grid for gas turbines. Methods of route analysis are described, and the policy behind reserves is discussed with statistical evidence. Detailed figures for allowances and various methods of route-analysis calculation are given in appendixes. The use of wind-frequency curves is described with reference to "fixed sector fuel" and "minimum pay load" operating techniques.

In conclusion, it is possible to set certain general rules for design: (1) the aircraft must fit the task to be performed in terms of the route conditions, frequency of operation, size of load, etc.; (2) the pay load-range characteristics should always relate to the critical sector of the intended route, though not to the worst conditions on that route; (3) for optimum economy, the pay load on this critical sector should still be sufficient for the full number of passengers and for the first-class mail commitment, thus securing the whole of the most paying items of revenue (this may require modification on routes with a strong prevailing wind in one direction, otherwise the design will "fit" only the critical direction); (4) the tankage should be sufficient for overflying any airport on the route, even if the pay load is thereby reduced considerably; and (5) the engine design must be geared to that of the aircraft and the main engine parameters adjusted to the critical conditions.

Utilization Factors and Maintenance of Civil Airplanes

Warren Alberts, Special Assistant to the Vice-President—Operations, United Air Lines, Inc.

The purpose of this paper is to present the principal factors that affect the utilization and maintenance of civil transport aircraft and to point out how these factors are being approached to achieve the most profitable operation. Since maintenance to produce a serviceable aircraft represents a sizable portion of operating costs and directly influences the availability of aircraft, it has received particular emphasis. The principal factors discussed are as follows:

Meeting or Awaiting Traffic Demand.—This represents actual use of the aircraft and depends on the air-lines route structure, schedule pattern, method of operation, and type of aircraft. Route segmentation, traffic inducements, central control of routing combined with central knowledge of demand, and development of a flexible routing pattern are steps to be taken in effectively utilizing a serviceable aircraft.

Ground Servicing and Handling.—This is a function of aircraft size, ground handling and service characteristics, facilities and equipment, manning, and operating procedures. The immediate approach in this case is one of improving ground-handling methods and equipment and obtaining optimum manning under planned workload conditions.

Line and Overhaul Maintenance.—Line and overhaul maintenance requirements differ only in frequency and size of job.

A detailed analysis of line and overhaul maintenance problems has been made over the past two years to determine the principal steps necessary to achieve the goal. They are as follows: (1) reduction to a minimum of the number of places at which maintenance work is performed; (2) provision of a uniform flow of work in units of equal size; (3) provision of adequate facilities to perform maintenance work; (4) introduction of proper work planning and man-power controls; (5) evaluation of each inspection or maintenance element to determine if it is essential, if frequency is right, and if method is correct; (6) introduction of the inspections required to reduce unpredictable failures and initiate action on permanent fix; (7) development of simple quantitative and qualitative tests to eliminate removal and tear-down of aircraft units; (8) utilization of production techniques and standard crews on periodic inspections; and (9) centralization of the control of the aircraft routing and of scheduling of periodic inspections. This discussion includes the progressive overhaul system, the dock method of maintenance, and Sched-U-Graph, the method of monitoring daily utilization, and use of the mean T.S.O. to control work flow into the overhaul base.

Second International Co

FOR THE SECOND TIME in less than 2 years, members of the two foremost aeronautical professional bodies of the world gathered together last May 26 for an International Conference Dinner.

This time, the Institute of the Aeronautical Sciences played host in return for the hospitality so memorably extended by the Royal Aeronautical Society in September, 1947. The scene at the Hotel Astor, although lacking the historic background of the Guildhall affair in London, lacked nothing in the enthusiasm and confidence with which both British and American participants regarded the Joint Conference and looked forward to the success of future meetings.

Describing the Second Joint Conference between the two societies as "a practical example of effective partnership between the world's greatest air powers," William A. M. Burden, President of the I.A.S., hailed the friendship that "can once again provide the basis for a common defense for western civilization" should the need arise.

Diverse Attitudes

As to the technical sessions just then concluded, Mr. Burden observed: "No one who has been present at these sessions could fail to be impressed by the difference of approach of the British and American participants and convinced of the value of bringing these diverse attitudes together in the same atmosphere over a period of days and weeks.

"The difference," he said, "is hard to define, but it reflects, I believe, the concentration on the abstract and intellectual in the British and continental educational systems as contrasted to the emphasis on the practical and the empirical which characterizes American education and technical training.

"Both types of brains, both kinds of approach," declared Mr. Burden, "are necessary to solve the formidable problems that confront aviation at this challenging and fascinating period of its development.

"These differences," he continued, "were also reflected in attitudes toward specific problems. The great emphasis that our British friends place on the propeller turbine in contrast to the relatively secondary position that it has been given in American development is a warning signal for the need of re-evaluation of our own position. This problem," he said, "should be of particular interest to American air-line operators."

Hopes for American Emulation

Mr. Burden commented upon the "meticulous manner" in which the British delegates prepared major

Conference Dinner

theses, despite busy everyday schedules, and which aroused the admiration of our own engineers to a point which "I hope," he emphasized, "will result in eventual emulation.

"Similarly," President Burden continued, "the discussion by American speakers of practical operating problems of helicopters and transport aircraft has brought a healthy note of reality to a program that might otherwise have been overbalanced on the theoretical side."

In Mr. Burden's view, the joint conference of the R.Ae.S. and I.A.S. held great hopes for the more distant future. Because the talents of unusually gifted people are required in aeronautics for the discovery of new phenomena, the creation of new concepts, and the gaining of insight, and because these persons appear in the population only in limited numbers, the chance of attracting such minds to aeronautics is greatly increased by having the human resources of both countries to draw upon.

Silver Medal Awarded Sikorsky

Igor I. Sikorsky, eminent helicopter designer for whom the British hold a high regard, received a special honor from the Royal Aeronautical Society when Sir John Buchanan, its President, presented him with the Society's Silver Medal.

It was the first time an American was presented with this high honor by the R.Ae.S., which is given for important advances in aircraft or engine designs.

I.A.S. Past-President (1947) Preston R. Bassett, President of Sperry Gyroscope Company, who presented to Capt. J. Laurence Pritchard, Secretary of the R.Ae.S., the Honorary Fellowship scroll of the Institute awarded him last January, made a short speech in which he lauded him for the great assistance he provided Major Lester D. Gardner in the founding of the Institute through his advice and experience.

In accepting the scroll, Captain Pritchard remarked, with a twinkle in his eyes, that "in my country, when a man is eulogized in this manner, he is about to die, and," he added, looking at the sober dark ribbon tying the scroll of Honorary Fellowship, "this would appear to confirm my thought." Nevertheless, he was greatly honored to receive the Fellowship, observing that there were only five persons who were Honorary Fellows of both societies. Four of these were present at the Dinner.

The new Foreign Honorary Fellow went on to reminisce about his friendship with Lester Gardner and

(*Continued on page 51*)

Memoirs of the I.A.S.-R.Ae.S. Conference

Photo Courtesy British Overseas Airways Corporation

by WELMAN A. SHRADER

NOW THAT OUR FRIENDS from Great Britain have come and gone, we can calmly evaluate the accomplishments of our joint meeting in the light of day. The long-range planning and pressure of details involved in arranging and conducting a conference of such magnitude has made earlier evaluation impossible. We have been too deep in the woods to see the trees.

At the time of this writing, 2 weeks after the final event, the Second International Conference may be written off as a success. The avowed purpose of the Conference, "the interexchange of aeronautical technical information," was accomplished to a large degree through the presentation of 23 well-prepared papers. Since all of these papers, together with discussions, are presently being published in a single volume of PROCEEDINGS, a fuller evaluation of their collective importance may be adjudged later.

The 3-day technical sessions (summarized in a preceding article) provided the background and set the tempo for the entire 2-week program. Important as they are, however, technical sessions alone can never be used as yardsticks for measuring the full value of scientific meetings. Of equal, if not greater, benefit to all concerned are those social functions and informal get-togethers where people learn to know each other.

Two solid weeks of meetings, plant visits, field trips, and social affairs gave our British guests and many members of the Institute ample opportunity to become acquainted. Undoubtedly, a better understanding of our mutual problems and a stronger bond of friendship has resulted.

To provide both our guests and I.A.S. members with a record of the meetings, the following illustrated diary has been compiled for this souvenir edition of the REVIEW.

Reception at I.A.S. Headquarters
May 23

An informal buffet supper, given by the Officers and Council of the Institute, marked the official opening of the Second International Conference between members of the Royal Aeronautical Society and the Institute of the Aeronautical Sciences. Held in the Institute's New York headquarters building at 2 East 64th Street, it was also the occasion for the first public showing

of the recently revitalized Aeronautical Archives and Museum.

One hundred and fifteen persons, including 64 British delegates and wives, attended the reception and supper. No formal speeches were made, the entire evening being devoted to welcoming our guests and acquainting them with the Institute's facilities and executive personnel. Since many of the delegates were visiting this country for the first time, this informal reception broke the ice and got the Conference off to a good start.

Technical Sessions and Luncheons
May 24, 25, and 26

The Hotel Astor provided the setting for the more serious aspects of the Conference and served as headquarters for the majority of the delegates during their stay in New York. Technical Sessions, held in the North Ballroom of the Hotel, got under way promptly at 9:00 a.m. the morning of May 24, with opening addresses of welcome by the Presidents of the two organizations. (See pages 16–17.)

The rigors of these sessions were broken daily through informal luncheons held in the East Ballroom. Guest speakers at the luncheons on the three respective days were T. P. Wright, Grover Loening, and Capt. J. Laurence Pritchard.

More detailed information regarding the Technical Sessions and luncheon addreses will be found on pages 18–33.

Conference Dinner and Reception
May 26

A reception for the Guests of Honor preceded the formal dinner on May 26 and was attended by the British delegates and wives. Approximately 500 Institute members and guests were present for the dinner that was served in the Grand Ballroom of the Hotel Astor.

W. A. M. Burden, I.A.S. President, acted as toastmaster and delivered the address of welcome. In reply, Sir John Buchanan, President of the R.Ae.S., expressed thanks on behalf of the British contingent and voiced the opinion that these joint meetings would become increasingly more valuable to the industry and governments of both countries.

Further highlighting the evening's program were the presentations of two awards. The Royal Aeronautical Society Silver Medal was presented to Dr. Igor I. Sikorsky for his outstanding work in helicopter development. Captain J. Laurence Pritchard received the Institute's 1948 Honorary Fellowship. More detailed information about these presentations may be found in the preceding story.

Sir Frederick Handley Page, guest speaker for the occasion, gave an extemporaneous talk that combined wit with common sense and appealed to his American audience. Excerpts from his speech are also contained in the preceding coverage of the dinner.

Grumman, Republic, and Ranger Plant Visitations
May 27

In spite of the arduous schedule of the 4 preceding days, 8:30 a.m. Friday found the majority of official British delegates boarding private buses for an all-day visit to Long Island aircraft plants. The first stop was Bethpage, where the party spent the morning inspecting the operations and facilities of the Grumman Aircraft Engineering Corporation. In addition to viewing the Mallard, Widgeon, and military airplane production shops, the group was treated to an impressive flight demonstration of the Grumman Panther.

Luncheon, with Leroy R. Grumman, Chairman of the Board of Grumman Aircraft, acting as host, was served at the plant.

The afternoon was divided between visits to Republic Aircraft Corporation and the Ranger Aircraft Engines Division of Fairchild Engine and Airplane Corporation, at Farmingdale. At the former, principal interest was centered around the final assembly line of the Republic P-84 Thunderjet. A fly-by demonstration of this plane was given before the group departed.

In addition to inspecting the Ranger engine plant, the party was taken on a tour of the Stratos Corporation and Al-Fin divisions of Fairchild, where production methods proved of particular interest.

Private buses returned the party to New York, depositing a foot-weary but still-enthusiastic group of visitors at the hotel around 6:30 p.m.

Sperry Tour, Aviation Country Club Garden Party, and Loening Reception
Saturday, May 28

A bus trip to McArthur Field, Long Island, for a demonstration of the Sperry Blind Landing System was the first event on this day's agenda. The Sperry Company had two C-54's completely equipped and on the line for demonstration purposes. All delegates were given an opportunity to take a flight during the morning and to observe the practical application of Sperry's navigational instruments and Blind Landing System.

The picture on the front cover of this issue shows the group that attended this well-planned and impressive demonstration.

A buffet luncheon and garden party at the Aviation Country Club, Hicksville, L.I., was the attraction for the afternoon. The ladies joined the party at this point and the entire group enjoyed a leisurely luncheon and afternoon of flying. Practically every type of American personal aircraft was represented on the line, and guests were invited to take flights in as many of these as they desired.

Additional entertainment was provided through flight demonstrations of Goodyear's cross-wind-landing-

A Day in Se

(Above) Bill Odum and his record-breaking Beechcraft Bonanza arrive at the Aviation Country Club, Hicksville, L.I.

(Above, left) Mr. and Mrs. W. F. Spurr, and Mr. and Mrs. F. M. Owner are interested spectators. *(Below, left)* Major Lester D. Gardner, founder of the Institute, enjoys seeing many of his old friends from England; in this case, Capt. C. F. Uwins, Managing Director (Aircraft), The Bristol Aeroplane Company, Ltd., and Treasurer of the Royal Aeronautical Society.

(Below, left) Mrs. and Mr. Christopher Clarkson contributed much to the success of the party. Mrs. Clarkson acted as hostess for Grover Loening's reception. "Chris," as British Air Attache to the U.S., handled many of the arrangements for getting his countrymen across the Atlantic for the Conference. *(Below, right)* Mr. H. G. Conway, Technical Director, British Messier, Ltd.

Day in the Country

Saturday, May 28

(Right) Dr. D. M. A. Leggett and J. H. Argyris, two members of the Royal Aeronautical Society staff, give Bill Odum's Bonanza the "once-over." *(Below, right)* On their way to the flight line to take a ride in the Sikorsky helicopter, Mr. and Mrs. Christopher Dykes obligingly pause for a snapshot.

(Above) The terrace of Grover Loening's home on Long Island offers a picturesque setting for a reception, while the fireplace of his living room, *(right)* proves an ideal spot for some after-dinner "hangar-flying."

Scenes at "Florham"

The Country estate of Miss R. V. Twombly, at Convent, N.J., provided the picturesque setting for these candid-camera shots by Allan D. Emil, I.A.S. Counselor. *(Top, left)* A portion of the group on the terrace. *(Top, right)* Admiral L. B. Richardson amid beautiful surroundings, including *(left to right)* Mrs. Richardson, Mrs. Allan Emil, and Mrs. W. A. M. Burden. *(Center)* One of the side porches and gardens of Florham. *(Bottom, left)* Group leaving the cattle barns. *(Bottom, right)* The miniature golf course drew the interest and attention of British and Americans alike.

gear-equipped DC-3 and Sikorsky's latest helicopters. Bill Odum, and the Beechcraft Bonanza in which he recently made his record-breaking transpacific flight, were also on hand.

Around 6:00 p.m., the group departed for Mill Neck where Grover Loening entertained the party with a highly enjoyable reception and buffet dinner at his estate.

Earl D. Osborn's Garden Party
Sunday, May 29

A leisurely trip up the Hudson River by private cars and buses to Garrison, N.Y., started this day at 10:30 a.m. Here, at the country estate of the father of Earl D. Osborn, President of the Edo Corporation, the guests were entertained at luncheon.

In the early afternoon, the party was driven across the river to West Point and shown some of the interesting and scenic spots around our U.S. Military Academy.

W. A. M. Burden's Garden Party
Memorial Day, May 30

This being an American national holiday, no plant visitations or official events were scheduled. Instead, an invitation was extended to all visitors by I.A.S. President, W. A. M. Burden, to enjoy a day of relaxation and pleasure at the country estate of his aunt, Miss R. V. Twombly, in Convent, N. J.

A more beautiful spot than "Florham" for a day's outing could scarcely be desired. With miles of countryside, gardens, and farm facilities to explore and an indoor swimming pool, tennis courts, and miniature gold course at hand, everybody was able to find something to do to match his athletic inclinations.

Like millions of other New Yorkers, our British guests returned to the City Monday evening in the midst of a typical, holiday-weekend traffic rush.

The Circle Tour
May 31 Through June 2

Even the weatherman smiled on the Second International Conference. With a 3-day tour by air scheduled to cover the prearranged visitations, unflyable weather could have upset many well-laid plans. As it was, the entire trip was made under practically cloudless skies.

The tour started early Tuesday morning with a bus trip to LaGuardia Field where American Airlines played host. After an inspection of its facilities, American flew the entire party to Washington in one of its DC-6 Flagships.

Major General Laurence S. Kuter took over at this point and initiated the visitors into the whys and wherefores of his successfuly run Military Air Transport Service. This included a tour of M.A.T.S. Andrews Field facilities and an especially prepared series of exhibits portraying the Service's operations. The latter clearly illustrated everything from the operation of the Berlin Air Lift to "How to Survive in the Florida Everglades." Actual dishes of cooked rattlesnake, alligator, and edible plants—not to mention snails and insects—were available for the asking. (Not too many "asked"!) Nobody, however, turned down the luncheon that was served before the group left the Field.

Private cars were supplied by I.A.S. Washington Section members for a mid-afternoon tour of some interesting spots in and around the Nation's Capital. Once again, the ladies joined the party to share in a portion of the day's social activities.

The sightseeing trip around Washington included a visit to Mt. Vernon, where Sir John Buchanan solemnized the occasion by placing a wreath on the tomb of America's first president.

In the early evening the State Department held a reception for the group at the Wardman Park Hotel, which was attended by many American notables in addition to the British guests.

A dinner at the Mayflower Hotel, arranged by the Washington Section of the I.A.S., concluded the program for the day. T. P. Wright acted as toastmaster for the evening, and the Honorable Delos W. Rentzel, Civil Aeronautics Administrator, was the guest speaker. Mr. Rentzel gave an outline of the C.A.A.'s program in the development of navigational aids and the establishment of blind-landing facilities at airports.

Wednesday, June 1.—The delegates were taken by bus from the Mayflower Hotel to the Washington airport early this morning for a flight to Langley, Va. M.A.T.S. provided a "plush" C-97 Boeing Stratocruiser for the air lift and deposited the group at Langley Air Force Base about 10:00 a.m. Here the day was spent inspecting the extensive aeronautical laboratories and wind tunnels of the National Advisory Committee for Aeronautics.

Luncheon was served at the Laboratories, and N.A.-C.A. personnel did their usual good job of putting on an interesting show.

At 4:30 p.m., the group departed by bus for Williamsburg, Va., to view this historic restoration and spend a quiet night at the famous Williamsburg Lodge.

Thursday, June 2.—This was "Navy Day" for the British contingent, with the Navy supplying the air lift and running the entire day's performance. Two R4D's were dispatched to pick up the guests at Langley Field and fly them to the Naval Air Station at Patuxent River, Md.

Rear Admiral Appolo Soucek played host at this point, giving the visitors an interesting demonstration of the Station's flight testing and experimental facilities. An impressive flight demonstration by a Chance Vought Cutlass and rides in the Piasecki helicopter provided additional thrills. A luncheon at the Officers Club concluded the morning program.

At 1:30 p.m. the group took off in Navy planes for Philadelphia. Here, at the Naval Air Material Center, Rear Adm. F. W. Pennoyer, Jr., gave the party a good idea of the extensive operations carried on at this Base.

Once again Naval aircraft provided the air lift, landing the group back in New York at 6:00 p.m. and successfully concluding the 3-day Circle Tour.

Curtiss-Wright Day
Friday, June 3

Those of our guests who were still able to navigate climbed aboard buses at 9:00 a.m. for a day-long visit to the Curtiss-Wright plants in New Jersey. The morning was devoted to a tour of Wright Aeronautical Corporation's engine manufacturing facilities at Wood-Ridge.

The group then proceeded to Caldwell to learn something about the activities and operations of the Curtiss-Wright Propeller Division. Luncheon was served at this plant.

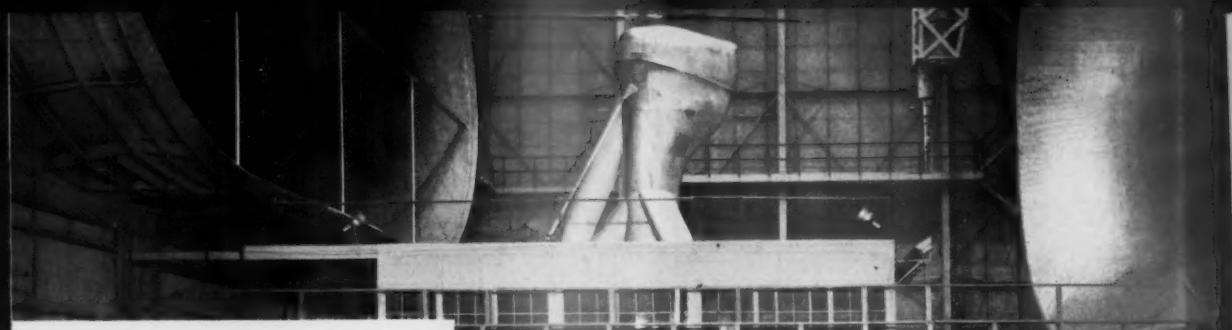
This enlightening tour came to a close around 5:30 p.m., when the group disembarked at the Hotel Astor in time to dress for the reception and dinner scheduled for the evening.

The Farewell Dinner

As a fitting climax to the 2-week program, the Officers and Council of the Institute gave a farewell dinner for the British delegates and their ladies. This was held in the Rainbow Grill atop the R.C.A. building at Rockefeller Center.

In the words of one of the guests, this setting provided .... "the inspiration for some lofty ideals and high-sounding speeches, in addition to giving one an unexcelled view of New York City."

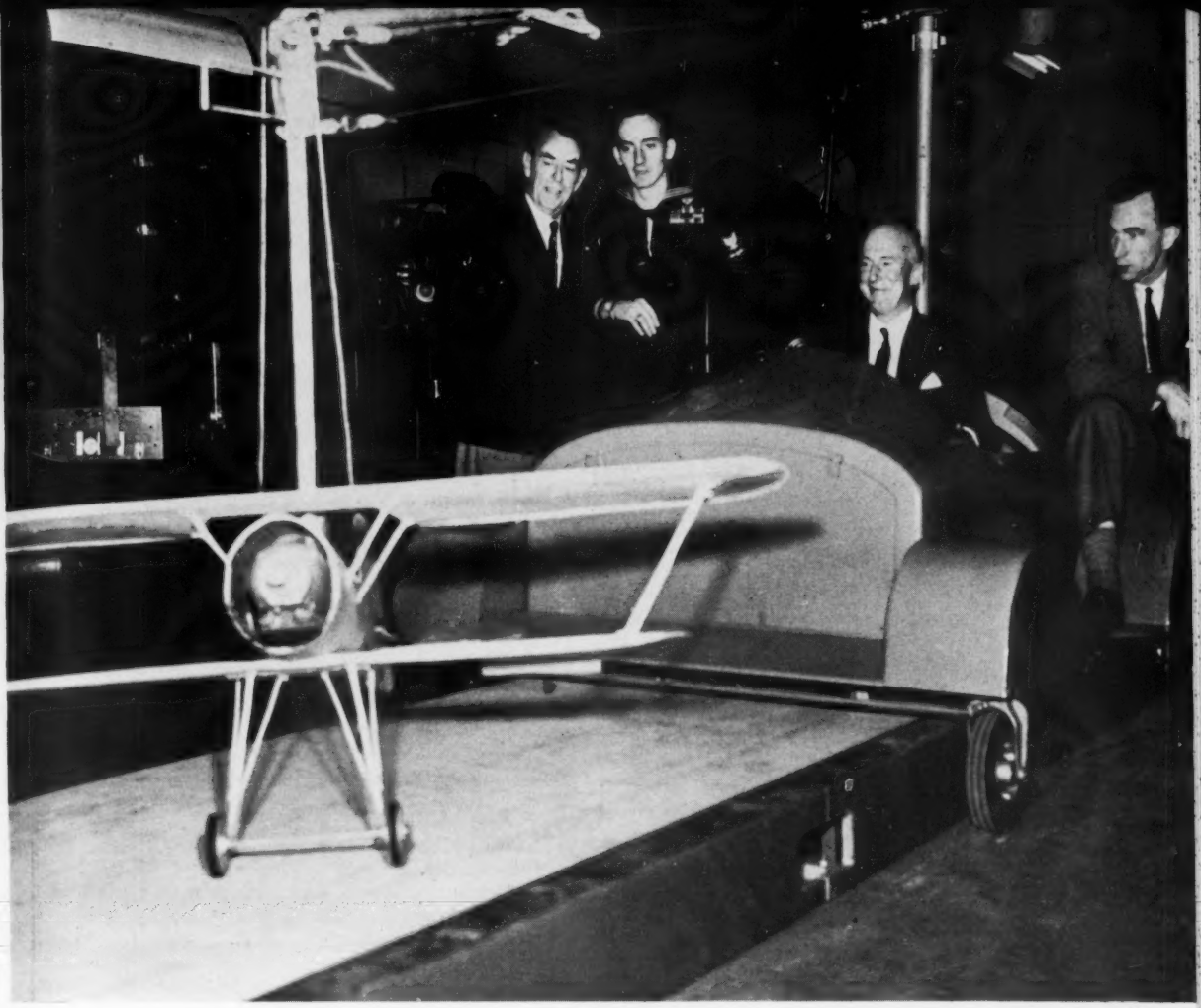
Formal thanks, goodbyes, and best wishes were voiced in brief speeches by each of the officers of both Societies at the conclusion of the dinner.



The Grand Tour

May 3
June

Many photographs were taken of the group during their tour around the Eastern Seaboard. Space permits the reproduction of only a few typical ones, such as: *(above)* Inside N.A.C.A.'s full-scale wind tunnel at Langley Aeronautical Laboratory. *(Left)* Inspecting an Air Rescue Survival boat of the Military Air Transport Service at Andrews Field, Washington, D.C. *(Below)* A briefing during the visits to the Philadelphia Naval Air Material Center.



(Above) At the Navy Special Devices Center, Sands Point, L.I., D. L. Hollis-Williams tries his hand at flying the Navy's Primary Flight Trainer, with evident enjoyment and the apparent approval of Capt. J. Laurence Pritchard *(left)*.

(Below) Ray Young, Vice-President—Engineering, Wright Aeronautical Corporation *(second from left)*, explains the high-temperature fatigue-testing machine used at Wright's Wood-Ridge, N.J., plant.

A Last Visit to Long Island
Saturday, June 4

While many of our visitors were scheduled to depart today, a final program was arranged for those who remained. This included a tour of the U.S. Navy Special Devices Center, at Sands Point, L.I., beginning at 9:00 a.m., with a luncheon served in the Officers Club at noon.

Toward mid-afternoon, the group was taken to La-Guardia Field for an inspection of Pan American Airways Training Center and a demonstration of the new Diehmel crew flight trainer, built by Curtiss-Wright.

The program ended at 6:00 p.m. when the guests were returned by bus to the Hotel Astor.

In Retrospect

Now that we look back over this diary, we have an even greater admiration and respect for the stamina and good humor of our British visitors.

Those who faithfully followed the planned, 2-week schedule (as many did) had little opportunity for resting weary feet. To them, we take off our hats.

The visiting ladies showed equally good sportsmanship in following the program mapped out for them. Where possible, the ladies were invited to participate in the proceedings of the official Conference delegates. At other times, they had their own program of teas and tours, arranged by a Ladies Committee headed by Mrs. W. A. M. Burden.

All in all, it was an interesting show. We hope that our guests from abroad enjoyed and profited by their visit to America as much as we did by having them here.

Roster of British Delegates
Attending the Second International Conference
New York City, May 23–June 4, 1949

Argyris, J. H., Technical Staff, R.Ae.S.
Baker, H. P., Ministry of Supply
Bass, E. L., Chief Engineer, Aviation Department, Shell Petroleum Company Ltd.
Broadbent, E. G., Structures Department, R.Ae.S.
Bradbrooke, Mrs. J., Editor, R.Ae.S.
Buchanan, Sir John, President, R.Ae.S.
Chaplin, Roland H., Assistant Chief Designer, Hawker Aircraft Ltd.
Clarke, J. S., Head of Research Section, Joseph Lucas
Clarkson, C., Civil Air Attaché, British Embassy
Constant, H., Director, National Gas Turbine Establishment, Ministry of Supply
Conway, H. G., Technical Director, British Messier Ltd.
Crewe, P. R., Aeronautical Technician, Saunders-Roe Ltd.
Davidson, E. G., Angelo Iranian Oil Co. Ltd.
Davies, Handel, Aero Flight Department, R.A.E.
Douglas, G. P., Aerodynamics Department, R.A.E.
Dykes, Christopher, Deputy Chief Project Engineer, B.O.A.C.
Edwards, G. R., Chief Designer, Vickers-Armstrongs Ltd.
Faggetter, E. F., Esq., Dunlop Rubber Australia, Ltd.
Hadfield, Peter, Assistant Civil Air Attaché, British Embassy
Haerle, H. R., Chief Technician, The Hymatic Engineering Company Ltd.
Hall, A. A., Professor, Imperial College
Handley Page, Sir Frederick, Managing Director, Handley Page Ltd.
Hollis-Williams, D. L., Chief Engineer, Fairey Aviation Co. Ltd.
James, Thurstan, Editor, *Aeroplane*
Jones, E. T., Director, Research and Development (Instruments), Ministry of Supply
Keith-Davies, E., Esq., Director, Cambrian Airways
Keith-Lucas, D., Chief Designer, Short Brothers & Harland Ltd.
Kerr, C. E., British Joint Services Mission
Lee, G. H., Chief Aerodynamicist and Chief of Research, Handley Page Ltd.
Leggett, D. M. A., Deputy Secretary, R. Ae.S.
Lombard, A. A., Chief Designer (Projects), Rolls Royce Ltd.
MacGregor, E. I. R., Assistant Civil Air Attaché, British Embassy
McAlpine, G., Technical Advisor and Manager, Kelvin Bottomley & Baird Ltd.
Owner, F. M., Chief Engineer (Engines), Bristol Aeroplane Company Ltd.
Pardoe, J. G. M., Design Staff, Air Registration Board
Petty, G. E., Chief Designer, Blackburn Aircraft Ltd.
Pribram, E., Technical Staff, R.Ae.S.
Pritchard, J. Laurence, Secretary, R.Ae.S.
Radcliffe, F., Esq., Technical Assistant to Sir Frederick Handley Page
Reissner, E., Research Engineer, Factories Direction Ltd.
Richards, E. J., Chief Aerodynamicist, Vickers-Armstrongs Ltd.
Richardson, C. A., Sales Engineering Manager, Sperry Gyroscope Company
Russell, A. E., Chief Designer (Aircraft), Bristol Aeroplane Company Ltd.
Scott-Hall, S., Principal Director of Technical Development (Air), R.A.E.
Serby, J. E., Director of Military Aircraft Research Department, R.A.E.
Spurr, W. F., British Joint Services Mission
Stranks, Joseph D., Chief Experimental Engineer, Hawker Aircraft Ltd.
Squire, H. B., Aerodynamics Department, R.A.E.
Taylor, J. Lockwood, Professor of Aeronautics, Istambul Teknik University, Turkey
Teed, P. L., Deputy Head of Aeronautical Research & Development, Vickers-Armstrongs Ltd.
Uwins, C. F., Director (Aircraft), Bristol Aeroplane Company Ltd.
Walmsley, R. H., Director of Aircraft Requirements, Ministry of Civil Aviation
Whiteley, E. A., Wing Commander, R.A.F., Air Ministry
Wilde, Geoffrey, Chief of Experimental Compressor Section, Rolls Royce Ltd.
Williams, J. K., Technical Surveyor, Air Registration Board
Wills, H. A., Council for Scientific and Industrial Research, Australian Government Department of Supply
Wingfield, L. A., Solicitor, R.Ae.S.
Winny, H. F., Fairey Aviation Ltd.
Woodall, R. H., Chief Engineer, Rotax, Ltd.
Woodward-Nutt, A. E., Director of Civil Aircraft Research and Development, R.A.E.

Lady Visitors

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Mrs. Christopher Dykes
Mrs. F. M. Owner
Lady Handley Page
Miss Anne Handley Page
Miss Mary Handley Page
Mrs. J. Laurence Pritchard
Mrs. A. E. Russell

Grover Loening*

on

"Personal Aircraft Development"

Excerpts from the Luncheon Address Before the Second International Conference of I.A.S.-R.Ae.S.

RESPONSIBILITY FOR THE rapidly shrinking personal plane market was laid at the door of the light plane industry by Grover Loening, N.A.C.A. Consultant, in his address on May 25 before the Second International Conference of the Royal Aeronautical Society and the Institute.

One of the serious shortcomings of the industry, according to the veteran airplane designer, was the hesitancy of personal-plane manufacturers to incorporate into new models many known improvements, such as ability to land and take off in small areas, quieter operations, and lower landing speeds, because of added costs involved. Additional costs would kill the market, it was held by the industry.

"It is to be noted, however," Mr. Loening commented, "that few have tried to meet this market. There are many new customers," he declared, "who are not in the least interested in the presently certified personal aircraft but who would find an aircraft incorporating such new features of great interest because of the totally new fields of utilization that are opened up."

What Private Owner Really Wants

One point, however must be kept in mind, the speaker emphasized: The airplane must not be slowed down in its cruising speed by virtue of endowing it with these new features of low landing speed, quick take-off, quieter operation, and easier control and landing features.

"The private owner," he said, "really wants a noiseless, easy-to-fly, four-seater aircraft that will fly from zero to 200 m.p.h. Of course," Mr. Loening added, "this will cost money, and at the beginning the market will be limited. But we have all experienced these obstacles in early aircraft development. This mania for selling aircraft only because they are cheap and not because they can give a result that we can use, is—at least in my opinion—a completely false path to progress."

Citing statistics on personal-plane production from 1946 to the present, Mr. Loening summarized the reasons why our utilization of personal-plane flying has decreased so discouragingly as follows:

"(1) Planes actually do not go where the individual really wants to go—landings are almost always made at more or less remote airports. A car or a bus must be taken to the destination. The destination is generally in town for shopping or business, or at a country club for golf, or at a beach, or at a friend's country place. To meet the requirement of actually ending up where one really wants to go, as is done so conveniently in the automobile, means almost vertical landing or take-off. The more nearly this is approached, the more places one can go. If . . . . we were to have planes that could land under 30 m.p.h. and take off in a couple of hundred feet over a 50-ft. obstacle, we could meet many of the requirements, even to landing in a city or in town, a rooftop or landing strip. . . . . The N.A.C.A. has researched several wing sections and high lift devices that, coupled with boundary-layer control, would enable a high lift. . . . . Some are daily in use in the Armed Services—but not a single certified commercial plane today has incorporated in it any more than the most elementary such features."

Langley Research on High Lift Wings

"It is further of interest that recent Langley research on high lift wing sections has been extended, particularly in low drag type airfoils, to the lower Reynolds Number range of 3,000,000 to 6,000,000 suitable to personal aircraft speed ranges and size. Interesting results have been obtained which clearly demonstrate that ex-

* Consultant, N.A.C.A.

isting wing sections on personal planes can be easily modified to give higher speed than now obtained for the same power and higher lift at greatly reduced landing speed.

"At the Langley Laboratory, a Cessna high wing airplane is being fitted with various wing configurations to study improvement of take-off and landing characteristics. Boundary-layer control will actually be installed in connection with high lift flaps."

Inability to Fly in Bad Weather

"(2) Next in our order of difficulties is the inability to fly in bad weather, which brings with it uncertainty as to making a schedule, which in turn means that the owner cannot plan on a definite week-end with any degree of assurance. If he runs into foul weather, his plans go awry. This tough problem is one that, of course, air lines are also up against, but one of the means of solution at hand is to endow aircraft with complete maneuverability as a vehicle. This essentially means that they must be endowed with the ability to stop in the air and back up. Now a helicopter, of course, can do this, but unfortunately, because of its present stability insufficiency, existing helicopters are difficult to fly in blind conditions. . . .

"(3) A further limitation to wide use of aircraft is that it is not a good neighbor, because it makes altogether too much noise. This, too, has been the subject of research by the N.A.C.A. and 2 years ago was the subject of a convincing demonstration of a silenced airplane that the Langley Laboratory showed to the engineers present here today and on which research has since been greatly extended.

"A fundamental study of different muffler types has been made with a laboratory setup with controlled conditions of noise frequency and amplitude. A special contract has been entered into, and is currently in process of being completed, with the Aeronautical Research Foundation of Boston to study further and to simplify solutions for noise abatement. These N.A.C.A.-sponsored researches have already resulted in some extremely interesting conclusions and extremely promising ones, indicating that the noise of take-off of close-in flying of a private aircraft can be reduced to an acceptable level that no community could reasonably complain against. But the application of this to existing new certified personal aircraft production is lagging noticeably. Keen interest therein is being displayed hesitatingly, and there is much shrugging of the shoulders and dismissing of this feature as too costly. Is it too costly, when public acceptance is likely to greatly increase the market for orders—chiefly because close-in landing strips would be tolerated?

"(4) Flying characteristics of personal planes are not yet entirely foolproof, particularly as to spinning and spiral instability. Development of design features to avoid spinning characteristics and of research thereon has been extensively done for years by the N.A.C.A., and the industry is familiar therewith and, in this instance, has used much of the data—largely because of the C.A.A.'s strict requirements thereon. With the knowledge now available on this subject, there is no excuse whatever for a new design of a plane to be a bad spinner, and, if it is, the N.A.C.A. has developed research procedure that would quickly cure it.

"As to spiral instability . . . this feature is now the subject of current investigation on which some results have already been obtained by flight test at Langley Field, indicating that friction on aileron or rudder control systems can produce a condition of divergence when controls are free which may appear to the pilot to be spiral instability that actually is not present. Further research on controls is currently inclusive of flight investigation of interconnected aileron and rudder control in order to explore further a two-control operation to simplify flying.

"An additional element of control study, upon which analysis and research is currently being made, is to provide the airplane, endowed with high lift devices to slow it down; with sufficient control forces (both as to aileron and tail) to enable it to be flown in this slow régime with adequate safety. For example, spoilers have been developed which give adequate lateral control in company with full span flaps and ailerons, and studies have been made of boundary-layer application to give control forces on surfaces subjected to extremely low-speed airflow.

"(5) The landing gear of personal aircraft is subject now to two further developments of perfection that would greatly extend utilization. The first, of course, is the cross-wind landing ability that is obtained by castering landing-gear wheels. . . .

"The second feature not yet much developed but in the analysis stage is, again, a corollary that would accompany the use of high lift devices—that is, landing gear of long stroke that would allow a slow high lift configuration at high angle of attack on its glide path with no flare at all. Skill required for landing and room for landing would be greatly reduced accordingly."

Could Be Incorporated from Research Now

"All the aforementioned features," said Mr. Loening, "are indicated developments that could be incorporated from research either now completed or in progress, and there would result a personal plane that could be operated with much greater scope as to where one could go and much greater assurance of regularity, less noise, easier to fly, and safer to land in unprepared close-in areas under more difficult wind and weather conditions."

"Fortunately," he concluded, "we have in the N.A.C.A. laboratories the facilities and know-how to undertake the vast amount of research needed to provide the basic information upon which to establish a great new aircraft industry producing an air vehicle that can be so widely useful to individuals as to command an enormous profitable production."

PROCEEDINGS

Second International Conference

I.A.S.-R.Ae.S.

This volume will be the complete record of the three-day Technical Sessions held by the Institute of the Aeronautical Sciences and the Royal Aeronautical Society at a Joint-Conference in New York, May 24-26, 1949. It is to include the 23 full-length papers, plus illustrations, figures, etc., and all formal discussions presented. With an overall size of 7" × 10", the book is expected to contain over 700 pages and 200 illustrations. It will be available as soon after the meeting as possible, and will be the *only* place where any of the 23 full-length papers are published. (Preprints of individual papers will not be available.)

Quantity Printed Will Determine Price

Because of expenses involved, the number of copies printed must necessarily be confined to the number of advance reservations received. To print and bind a minimum of 500 copies will cost $15.00 per book; 750 copies can be produced for $12.50 each; or 1000 copies for $10.00 each.

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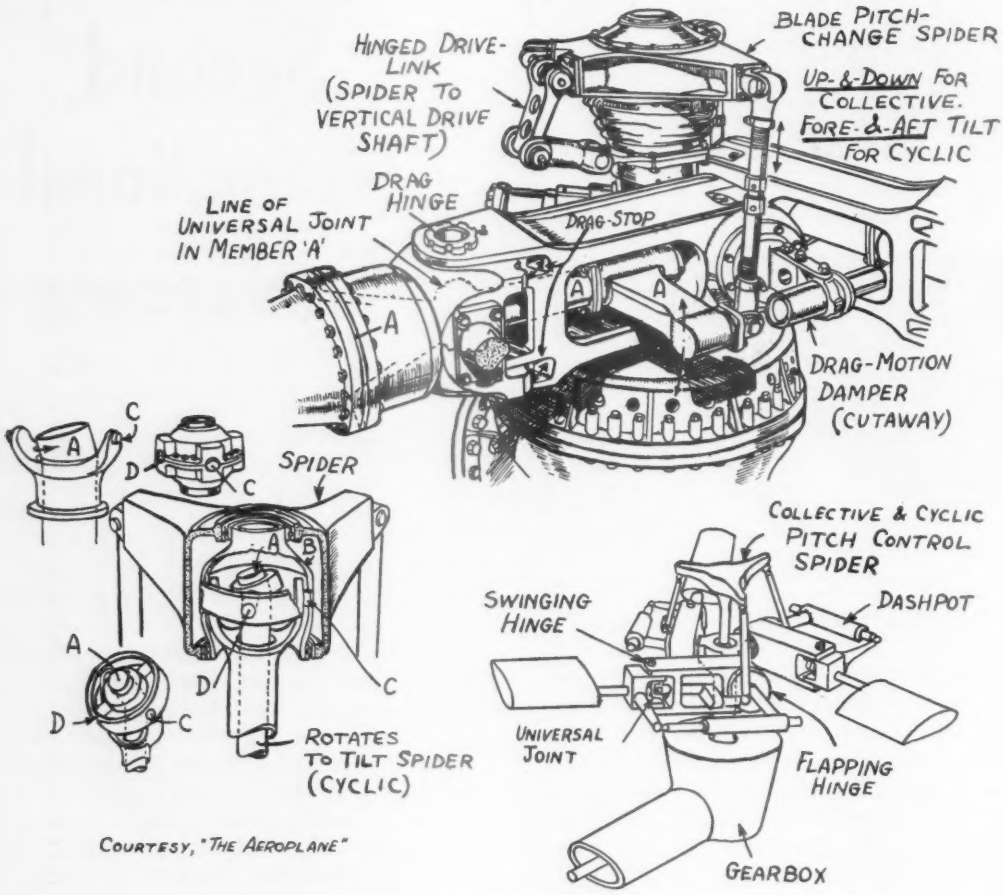
Design Trends



COURTESY, "THE AEROPLANE"

Cierva Air Horse

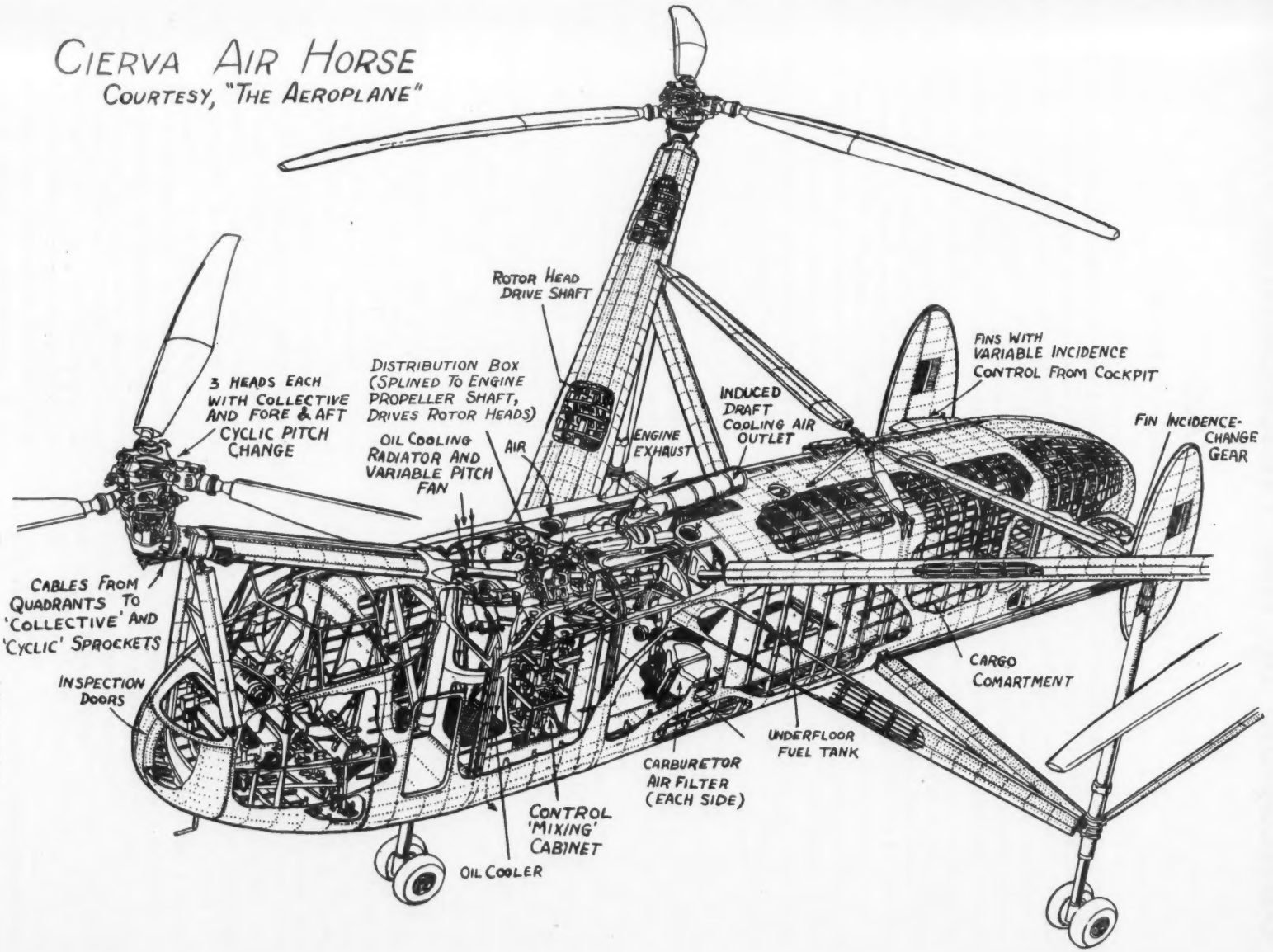
General Description: *The biggest British helicopter, the Air Horse, powered by a Rolls-Royce 1,620-b.hp. Merlin 24 engine, was first flown December 7, 1948, weighing some 14,000 lbs. Design gross weight is 17,500 lbs. Having the outward appearance of a transport fuselage* (**opposite page**) *to which are attached rotors in place of wings, the Air Horse is characterized by a triple rotor configuration and exceptionally long landing-gear legs. Carried on a triangulated outrigger system, the three rotors are arranged with the front rotor mounted over the nose and the two rear rotors mounted on booms and supporting members on either side of the fuselage and nearly on line with the tail fins. Rotating in the same direction, the rotors have built-in tilt, mainly in the lateral direction and counteracting resultant torque reaction. Differential application of collective pitch to the three rotors controls pitch and roll, and control about the yawing axis is accomplished by cyclic pitch variation in the fore-and-aft phase applied differentially to rear rotors. Lockheed landing gear, equipped with twin wheels on each unit, is installed. To enable it to absorb shock of extremely high rates of descent, the legs have vertical travel of 5 ft. Fuselage of rectangular cross section with rounded corners is a semimonocoque structure with pressed channel section frames generally spaced at 15-in. pitch, with some at 18 in. Frames are slotted and joggled over extruded bulb-angle stringers, which are continuous except at main frames to which front and rear rotor boom bracing members are attached. A two-place cockpit in the nose is provided with dual controls—entrance is through a small luggage compartment just aft.*

Air Horse Data: *Overall width, 95 ft.; length overall, 88 ft. 7 in.; height overall, 17 ft. 9 in.; rotor diameter, 47 ft.; distance between rotor centers fore and aft, 41 ft. 7 in.; distance between rear rotor centers, 48 ft.; track, 30 ft. 11 in.; wheelbase, 20 ft. 10½ in. Weight empty is 12,140 lbs.; fuel, 157 gal., 1,130 lbs.; oil, 15 gal., 135 lbs.; crew, two, 340 lbs.; pay-load with full tanks, 3,755 lbs. Estimated performance: maximum speed (sea level), 140 m.p.h.; maximum cruising speed, 116 m.p.h.; speed for maximum range, 95 m.p.h.; speed for maximum endurance, 55 m.p.h.; maximum still air range (normal tankage), 330 miles; maximum endurance (normal tankage), 4.3 hours; maximum vertical rate of climb (sea level), 790 ft. per min.; maximum inclined rate of climb (sea level), 1,210 ft. per min.; vertical climb ceiling (360 ft. per min.), 5,000 ft.; service ceiling (400 ft. per min.), 23,300 ft.; absolute ceiling (maximum altitude for level flight with maximum rating), 28,000 ft.*

Pitch Control Spider Operation: *Hub spider* (**above**), *including integral flapping pins carrying flapping links on ball and roller bearings, is mounted on the output shaft of the epicyclic gear train. Flapping axes of all three blades intersect on axis of rotation.*

CIERVA AIR HORSE

COURTESY, "THE AEROPLANE"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3 HEADS EACH WITH COLLECTIVE AND FORE & AFT CYCLIC PITCH CHANGE
OIL COOLING RADIATOR AND VARIABLE PITCH FAN
AIR
ENGINE EXHAUST
INDUCED DRAFT COOLING AIR OUTLET
FINS WITH VARIABLE INCIDENCE CONTROL FROM COCKPIT
FIN INCIDENCE-CHANGE GEAR
CABLES FROM QUADRANTS TO 'COLLECTIVE' AND 'CYCLIC' SPROCKETS
INSPECTION DOORS
CARGO COMARTMENT
UNDERFLOOR FUEL TANK
CARBURETOR AIR FILTER (EACH SIDE)
CONTROL 'MIXING' CABINET
OIL COOLER

Education of the Aeronautical Engineer

J. C. HUNSAKER*
Massachusetts Institute of Technology

THE DEPARTMENT OF AERONAUTICAL ENGINEERING at the Massachusetts Institute of Technology, as a result of a critical review of the current responsibilities of its graduates, has proposed a new program of graduate study designed to approach modern requirements† for professional engineering competence. Authority has been given for the award of the degree, Aeronautical Engineer, for the successful completion of this program. I give below a summary of the reasons that led to the program and an indication of its nature.

The objective of the usual undergraduate 4-year engineering course is to supply the fundamentals of a general education while preparing the student for useful employment in an engineering organization. The student is expected to acquire a sufficient introduction to scientific methods and professional techniques to profit by experience and to take advantage of the educational opportunities offered by his professional society, the Institute of the Aeronautical Sciences.

However, it is now believed that the S.B. student is no longer carried to an educational level adequate to take advantage of such opportunities. During the past 8 years, advances in aeronautical science and its applications to design have introduced a number of topics for which a professional engineer will be responsible in practice. These include transonic and supersonic aerodynamics, gas dynamics, aeroelasticity and dynamic loading of structures, automatic and servo controls, jet propulsion, rockets and guided missiles, gas turbines, compound engines, etc. To handle problems of this character, the engineer and designer needs a deeper understanding of physical phenomena and more powerful tools of applied mathematics. Moreover, to progress toward full professional competence, the junior engineer must be able to read and evaluate for use in design theoretical and analytical papers in the literature of his art. Too often he lacks the fundamental background to do this outside of the narrow range of a special topic.

It is clearly impracticable to include the essentials of the new topics in the undergraduate curriculum. Nor is it fair to the student to weaken his basic undergraduate education with survey courses of a necessarily superficial nature. Furthermore, not all students are headed for a strictly professional career. The majority go to work at the first opportunity and may become absorbed with practical matters of manufacture and operation where further academic training is not needed.

However, if the junior engineer aspires to the higher levels of professional engineering practice, such as research, design, and development, he should carry his academic education farther. Historically, the engineering profession in this country has tended to judge competence by experience, in contrast with the medical and legal professions where a degree from a special graduate school is considered a necessary prerequisite for admission to practice. The chemist and the physicist now seem to find it necessary to carry academic training through to the doctorate.

In the last 20 years, the advances in engineering science made by European-trained engineers have been out of all proportion to their numbers. In general, their academic training has been more thorough and less specialized. During the war, a remarkable number of new weapons and devices were based on the work of men with advanced training in a basic science rather than in engineering. While it is true that such new weapons and devices required experienced engineers to perfect and produce them in quantity, the fact remains that engineers were less apt to develop new concepts from first principles.

The practice of engineering is an art involving the exercise of judgment. The professional man is to be distinguished from the technician primarily by confidence in his professional judgment on the part of the client or employer. This position of trust is based on an assumed professional competence covering the broad field of his responsibility. The aeronautical engineer cannot be merely a specialist in aerodynamics, or structures, or some other one aspect of aeronautical science.

Whether an art such as aeronautical engineering involving judgment and choice can ever be taught is open to question. One is not taught to paint by watching a master or to play the violin by attending many concerts. In the school of architecture students learn their art by practice in design under criticism.

Aircraft design requires consideration of the problem as a whole and synthesis, by selection from all known techniques and information, of an optimum solution. Judgment is conditioned by practical limitations of materials, processes, and costs and is colored by final exercise of the imagination to foresee operating conditions and the probable satisfaction of pilots and passengers.

If the argument has been followed so far, these conclusions should be foreseen:

(a) The student preparing for professional responsibilities should follow a program of advanced studies in

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* Professor in Charge, Department of Aeronautical Engineering.

† Others are making similar examinations. See in particular "New Horizons in Engineering Education," by Dean Thorndyke Saville, *Jour. of Engr. Education*, Vol. 39, No. 7, March, 1949.

the Graduate School designed to give him a penetrating understanding of each of the main branches of aeronautical science. This requires that his program, while including such special topics as may be of primary interest to him, shall have a required core of courses in aerodynamics, structures, propulsion, instrumentation and automatic controls to give the broad base needed.

(b) These core courses should also include practice in design in which judgment is exercised and, it is hoped, developed and refined by criticism. The core of required subjects should constitute about one-half of the program.

Such a graduate program covering two academic years and leading to the degree of Aeronautical Engineer has been authorized at M.I.T. beginning in September, 1949. The objective is a broader base and a higher level of professional competence than is required by the program for the Master of Science degree and without the emphasis on intense specialization and creative research characteristic of a doctoral program.

A graduate of the Aeronautical Engineering Department of M.I.T. who enrolls for the Aeronautical Engineering degree, or others with equivalent preparation, may complete the requirements for that degree in four academic terms. Students with less extensive preparation in the field will require a longer time.

The formal requirements call for the satisfactory completion of an approved program comprising a substantial amount of advanced study and research, including a thesis that may take the form of a comprehensive design problem.

The core subjects are tabulated below:

FIRST YEAR	**First Term**	**Second Term**
	Applied Mathematics	Applied Mathematics
	Applied Aerodynamics	Airplane Structures
	Instrumentation and Control	Compressible Flow
		Propulsion
SECOND YEAR	**First Term**	**Second Term**
	Aeroelasticity	
	Design	
	Propulsion	Thesis
	Seminar	Seminar

Each term's program would be filled out to a full load by selection of a consistent sequence of elective subjects in some special aspect of the professional field.

Elective subjects in the Graduate School for those interested in aerodynamics include treatments of kinetics of gases, potential flow, viscous flow and boundary-layer mechanics, supersonic and transonic aerodynamics, and wind-tunnel research. Those primarily interested in structures might elect courses on the theory of elasticity, aeroelasticity, and dynamics of structures, with corresponding laboratory work. For automatic control studies, a graduate student might elect courses on theory of gyroscopic instruments, vibration measurement, airplane stability and control, and flight-test instrumentation and control systems. Those whose ambition leads toward design could elect courses on rotary-wing aircraft, airplane design practice, guided missiles, or on the various means of jet propulsion. The designer no longer may expect to meet his performance requirements through the kindly cooperation of a purchasing agent to supply a suitable engine. The designer is responsible for the complete performance of an aerial vehicle comprising a specialized air frame into which are incorporated its means of propulsion and control.

The suggestion that the young aeronautical engineer spend 2 or more years in the Graduate School in preparation for his life work may seem to be expensive and perhaps unduly to prolong his education, which otherwise might be completed by experience at the expense of his first employer. To this, a teacher can reply: Experience at the employer's expense is often a matter of chance and is usually of an intensely practical nature. Graduate training at the professional level is recommended only for a relatively small number of engineering students of demonstrated aptitude. The undergraduate program will automatically screen them, and by scholarship aid, loans, and part-time employment, promising men can be helped. Their case is certainly less burdensome to the family budget than that of a brother who prepares for a professional career in law, medicine, or science.

Second International Conference Dinner

(*Continued from page 35*)

the events leading up to the organization of the I.A.S.

A Great Part in Our Economy

Sir Frederick Handley Page, principal speaker of the evening, contributed what Mr. Burden called "the unique sandwich system of Handley Page construction, consisting of aviation, history, and humor" in his speech.

Calling upon his audience of engineers and scientists to see "a little beyond the curves and the charts" that form so important a part in aeronautics, Sir Frederick said that "from these proceedings and from these gatherings, we get a better appreciation of the problems ahead of us. "I believe," he said, "that aviation will play a very great part in our economy."

Turning to history, Sir Frederick apparently drew a parable between the fact that the East, once the center of civilization, was forced to accept Western ideas and modes, whereas the world now faces a similar acceptance of the airplane as a prime factor in our lives.

"With the advent of the airplane," he declared, "there is coming into our economy something as important as the ship was a long time ago."

The Dinner was adjourned, upon conclusion of Sir Frederick's speech, with some closing remarks by the I.A.S. President.

I.A.S. Briefs

Summaries of current papers accepted for publication or presentation at I.A.S. Meetings

Theory and Tests on the Plastic Stability of Plates and Shells

By
P. P. Bijlaard
Cornell University

Buckling of plates and shells superimposes an additional state of stress on the original one. Assuming that plastic deformation is governed only by the amount of elastic shearing energy at the point in question, the author shows that the assumption of "plastic deformation" leads to smaller buckling stresses than that of "plastic flow." Using the assumption of "plastic deformation," it is found that the theory is in good agreement with tests by Kollbrunner and by the N.A.C.A. It is found that the ratio between plastic and elastic buckling stress is highest when the proportions of the deviator components, as superimposed by buckling, differ most from the proportions of the original deviator components. The stress-strain relations are derived by writing the infinitely small excess strains as total differentials and computing the partial derivatives of the strains with respect to the stresses. The differential equation for plate buckling is derived, and results of its application to several kinds of loading and boundary conditions are tabulated. The theory for the buckling of shells is also given. The author presents a comparison of his theory with the theories of Ilyushin, Stowell, and Handelman and Prager.

Interaction Between Parallel Streams of Subsonic and Supersonic Velocities

By
H. S. Tsien and M. Finston
Massachusetts Institute of Technology

An essential feature of the interaction phenomena between the compression shock and the boundary layer is the coexistence of parallel streams of subsonic and supersonic velocities. The compression disturbance of the shock is propagated "ahead" of the shock through the subsonic portion of the boundary layer, and "softening" of the shock takes place. It is the purpose of the paper to demonstrate definitely this essential feature of boundary layer-shock interaction by using a simplified model: The boundary layer is replaced by a uniform subsonic stream of finite width, bounded on one side by the solid wall and on the other side by the interface with the uniform supersonic stream of infinite extent. The flow fields of two cases are analyzed in detail: (a) a compression wave in the supersonic stream incident upon the subsonic layer, and (b) outgoing compression waves generated by a sudden change in the slope of the solid wall. Both types of disturbances are assumed to be small, so that linearization of the differential equations is possible. A general result is that the distance of upstream propagation is directly proportional to the width of the subsonic layer. Therefore, when the boundary layer is turbulent and the subsonic layer is extremely thin, there is negligible softening of the shock.

Please do not order Preprints of these papers at this time.

See page 54 for Preprints that are immediately available.

Some Aspects of Convertible Aircraft Design

By
Robert L. Lichten
Bell Aircraft Corporation

This paper is a contribution toward a quantitative engineering treatment of convertible aircraft design. A brief discussion of design requirements and proposed configurations is given. The analysis covers the following:

(1) Conversion from helicopter rotor to propeller operation. A semigraphical process for computing rotor characteristics during the conversion process when blade-section inflow angles can no longer be considered small is presented. Calculations for a typical case indicate that when no unusual or undesirable rotor behavior occurs, blade flapping decreasing progressively from the magnitude existing in helicopter operation. The rotor is shown to operate efficiently throughout, indicating that aircraft performance is not impaired during the conversion interval.

(2) Rotor aerodynamic characteristics in propeller operation. It is shown that satisfactory propulsive efficiency can be obtained with isolated rotors having relatively low solidity and blade twist compared to conventional propellers. In order to obtain good efficiency at high forward speeds, it is necessary to operate the rotor at high pitch and power coefficient. In practice, this means that, when a helicopter rotor is converted to propeller operation, its tip speed must be reduced considerably. Model propeller test data are compared with calculations based on modified vortex theory, and it is shown that the calculation method yields reasonably accurate results for the somewhat unusual operating conditions of the rotor-propeller.

(3) Effect of gravity on a lag-hinged rotor in propeller operation.

The undamped in-plane motion due to gravity excitation of a lag-hinged rotor blade is analyzed for operation with rotor axis horizontal. In the case of a three-bladed rotor, it is shown that the resulting hub vibratory loads are negligible. In the case of a two-bladed rotor, the amplitude of the vibratory force applied to the rotor hub is considerably greater than total blade weight, and therefore a two-bladed convertible rotor probably must be of the semirigid or rigid type to avoid this condition.

On a Complete Solution of the One-Dimensional Flow Equations of a Viscous, Heat-Conducting, Compressible Gas

By

Morris Morduchow and Paul A. Libby

Polytechnic Institute of Brooklyn

The hydrodynamic equations describing the steady, one-dimensional flow of a viscous, heat-conducting, compressible gas are treated. The equation of state for a perfect gas is assumed valid, and the coefficients of specific heat are assumed constant. A complete integral of the energy equation is found for a Prandtl Number of $^3/_4$, which is a good approximation for the actual value of many gases over wide temperature ranges. A particular integral contained in this complete integral is $u^2/2 + c_pT =$ a constant, which is a frequently used one-dimensional energy equation. The restrictions on its use are rigorously derived and stated. With the complete integral of the energy equation, three different types of solutions which depend on the boundary conditions are shown to be obtainable. The usual shock wave solution (satisfying the Rankine-Hugoniot relations) is only one of these three types.

Several features of the shock wave solution are shown. For example, the entropy has a maximum value at the inflection point in the velocity distribution. The validity of the continuum hypothesis is examined, and it is shown that the thickness of the wave as defined by Prandtl becomes infinite as the initial Mach Number of the flow becomes infinite provided that n, the exponent in the temperature-viscosity relation $\mu/\mu_0 = (T/T_0)^n$ is greater than $^1/_2$. Furthermore, it is concluded that the continuum theory may give reasonably correct results for flows with Mach Numbers up to 1.3.

The other two cases of flows contained in the equations are terminating flows—i.e., flows that can be valid only in a finite region. Their mathematical nature is demonstrated by two numerical examples, which indicate compression shocks followed by expansion waves. However, the physical significance, if any exists, of such solutions remains open to question.

The Instability of Pitching Oscillations of an Airfoil in Subsonic Incompressible Potential Flow

By

Benjamin Smilg

Wright-Patterson Air Force Base

A theoretical study is carried out to determine the conditions under which steady-state pitching oscillations of an airfoil in one degree of freedom are possible in two-dimensional subsonic incompressible potential flow. The results show that such oscillations can occur if the airfoil moment of inertia is sufficiently great and if the axis of rotation is located at a point that is forward of the airfoil quarter-chord but not too far forward of the airfoil leading edge. The practical significance of these results with respect to flutter and airplane stabilty problems is briefly examined.

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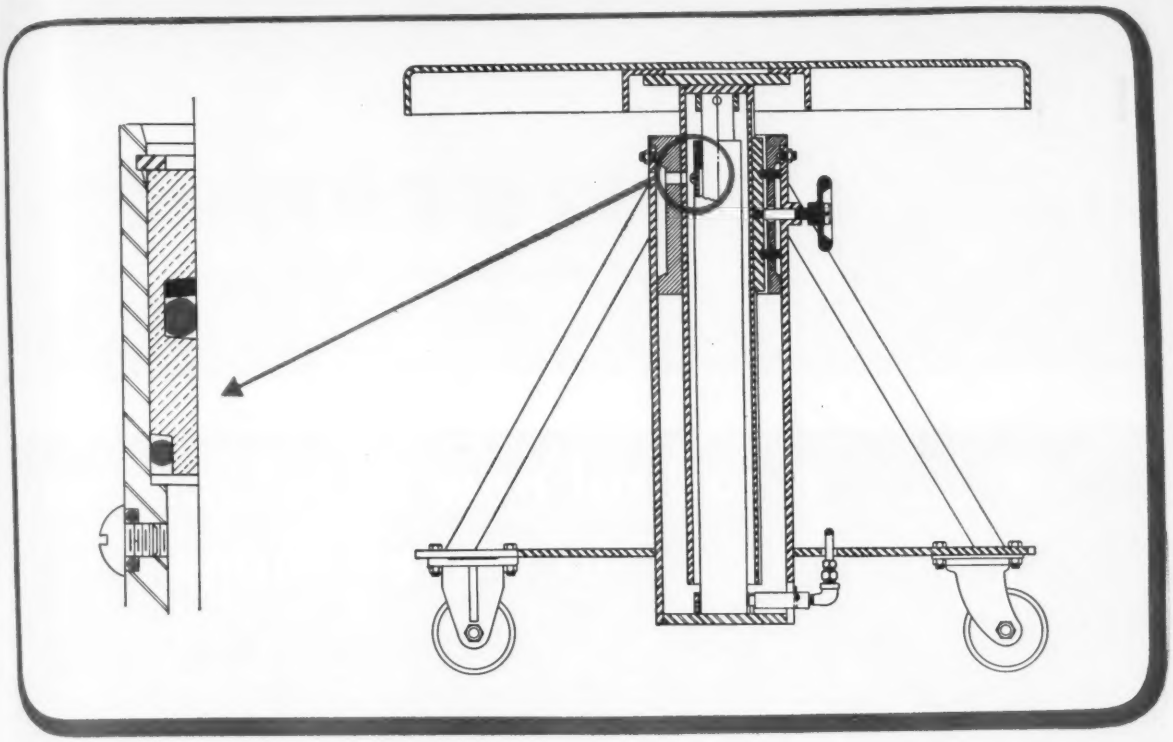

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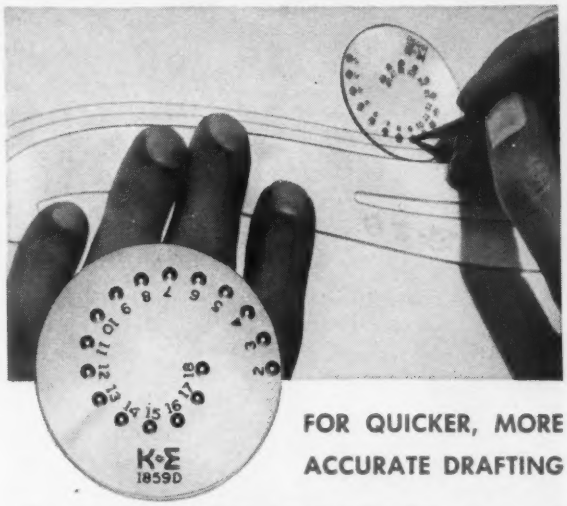

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Aerodynamics (2)

BOUNDARY LAYER

Some Considerations on the Development of Boundary Layers in the Case of Flows Having a Rotational Component. J. M. Burgers. (*Delft, Technische Hoogeschool, Laboratorium voor Aero-en Hydrodynamica, Mededeeling No. 40.*) *Nederlandsche Akademie van Wetenschappen, Verhandelingen*, Vol. 44, No. 1, 1941. 17 pp., figs. 5 references. (Reprint.) (In English.)

Equations for the flow in the boundary layer along a rotating wall and a surface of revolution show the effects of tangential velocity and rotation of the surface on the separation of turbulent and laminar boundary layers from concave and convex surfaces. In order to apply them to rotating aerodynamic machinery, the formulas are extended to take into account the centrifugal forces, the Coriolis effect, and the pressure distribution on the blades of a compressor or pump.

An Approximate Method for Calculation of the Laminar Boundary Layer With Suction for Bodies of Arbitrary Shape. H. Schlichting. (*Braunschweig, Bericht Nr. 43/13*, June, 1943.) *U. S., N.A.C.A., Technical Memorandum No. 1216*, March, 1949. 85 pp., figs. 20 references.

A method of approximation for calculating the laminar boundary layer with suction for arbitrary body contour and arbitrary distribution of the suction quantity along the contour of the body in the flow. It is related to the well-known Pohlhausen method for calculation of the laminar boundary layer without suction and requires the integration of a differential equation of the first order according to the isocline method. The method is applied to several special cases for which there also exist, in part, exact solutions: a plate in longitudinal flow and plane stagnation point flow with homogeneous suction. The circular cylinder and symmetrical Joukowsky profile with homogeneous suction are calculated as examples.

Measurements in Flight of the Pressure Distribution on the Right Wing of a Pursuit-Type Airplane at Several Values of Mach Number. Lawrence A. Clousing, William N. Turner, and L. Stewart Rolls. *U.S., N.A.C.A., Report No. 859*, 1946. 23 pp., illus., figs. 3 references. U.S. Govt. Printing Office, Washington. $0.20.

CONTROL SURFACES

Comparison of Experimental and Calculated Lift and Hinge Moment Parameters for Full-Span Control Surfaces. R. J. Templin. *Canada, National Research Council, Division of Mechanical Engineering, Aerodynamics Laboratory, Report No. MA-206*, May 21, 1948. 9 pp., figs. 3 references.

FLUID MECHANICS & AERODYNAMIC THEORY

The Potential Flow Around Given Wing Sections. Kwei-Lien Chang. *Journal of the Aeronautical Sciences*, Vol. 16, No. 4, April, 1949, pp. 306–310, figs. 3 references.

By the use of Wilton-Morris' parametric representation and the Kármán-Trefftz transformation, the complex potential around a given wing section can be given as an exponential series. This series is exact in the sense that the actual profile instead of the approximate one is used for its development.

Effect of Compressibility at High Subsonic Velocities on the Lifting Force Acting on an Elliptic Cylinder. Carl Kaplan. *U.S., N.A.C.A., Report No. 834*, 1946. 9 pp., fig. 10 references. U.S. Govt. Printing Office, Washington. $0.15.

An extended form of the Ackeret iteration method in which the velocity potential or the stress function is developed in a power series of a geometrical parameter characteristic of the body. The method, applicable to arbitrary profiles, is used to calculate the compressible flow past an elliptic cylinder. The angle of attack to the direction of the undisturbed stream is small, and the circulation is fixed by the Kutta condition at the trailing end of the major axis. The expression for the lifting force on the elliptic cylinder which is derived shows a first-step improvement of the Prandtl-Glauert rule. The expression for the lifting force, although derived specifically for an elliptic cylinder, may be extended to arbitrary symmetrical profiles.

The Compressible Flow Past Various Plane Profiles Near Sonic Velocity. B. Gothert and K. H. Kawalki. (Die kompressible Stromung um vershiedene ebene Profile in Nahe der Schallgeschwindigkeit. ZWB, Untersuchungen und Mitteilungen, Nr. 1471, January 6, 1945.) *U.S., N.A.C.A., Technical Memorandum No. 1203*, March, 1949. 51 pp., diagrs., figs.

Model calculations for profile flows worked out by the single-source method. The number of single sources in each flow gradient was fixed at twelve, so arranged that the single sources disposed along a stream filament, as much as possible, are of equal yield. The calculation was further simplified by postulating symmetrical flows. The single-source method shows at once whether the chosen number of approximation steps complies adequately with the continuity condition of compressible flow or whether the solution diverges, which indicates that at a particular Mach Number for the chosen profile symmetrical flow, free from compressibility shocks, is not to be expected.

The Drag Problem at High Subsonic Speeds. Adolf Busemann. *Journal of the Aeronautical Sciences*, Vol. 16, No. 6, June, 1949, pp. 337–344, illus., diagrs., figs. 4 references.

The problem is to find the real critical Mach Number in the theoretical sense—the first appearance of shock waves in a non-viscous fluid following given boundary conditions. It is known that some solutions of shock-free potential flow with a mixed subsonic-supersonic velocity pattern exist. This fact suggests that exceeding the sonic velocity is not critical. It can be shown, however, that the genuine potential flows with a mixed pattern are the exceptions. The flow past a given body at high subsonic speeds leads to a unique solution containing shock waves in most cases. This result settles many previously unanswered questions in the transonic speed range. The main conclusions can be extended to three-dimensional cases.

Sound Waves and Shock Waves. II. Roger Tennant and Peter Kahn. *The Aeroplane*, Vol. 76, No. 1970, March 11, 1949, pp. 271–273, illus., figs. A nonmathematical introductory treatment of the mechanics of airflow.

Linearized Compressible-Flow Theory for Sonic Flight Speeds. Max A. Heaslet, Harvard Lomax, and John R. Spreiter. *U.S., N.A.C.A., Technical Note No. 1824*, March, 1949. 45 pp., figs. 21 references.

The partial differential equation of the perturbation velocity potential for free-stream Mach Numbers close to and equal to 1. Under the assumptions of linearized theory, solutions can be found which are consistent with the theory for lifting surface problems both in stationary three-dimensional flow and in unsteady two-dimensional flow. Example solutions include a three-dimensional

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swept back wing and a two-dimensional harmonically oscillating wing, both for a free-stream Mach Number equal to 1.

On the Application of Statistical Mechanics to the Theory of Turbulent Fluid Motion; A Hypothesis Which Can Serve as a Basis for a Statistical Treatment of Some Mathematical Model Systems. J. M. Burgers. (*Delft, Technische Hoogeschool, Laboratorium voor Aero- en Hydrodynamica, Mededeeling No. 39.*) *Nederlandsche Akademie van Wetenschappen, Verhandelingen, Vol. 43,* Nos. 8, 9, 1940. 17 pp. 9 references. (Reprint.) (In English.)

Application of the Method of Characteristics to Supersonic Rotational Flow. Antonio Ferri. *U.S., N.A.C.A., Report No. 841,* 1946. 12 pp., diagrs., figs. 12 references. U.S. Govt. Printing Office, Washington. $0.15.

A system for calculating the physical properties of supersonic rotational flow with axial symmetry and supersonic rotational flow in a two-dimensional field which uses the characteristics method. The system was applied to the study of external and internal flow for supersonic inlets with axial symmetry. For a circular conical inlet, the shock that occurred at the lip of the inlet became stronger as it approached the axis of the inlet where it became a normal shock. The region in which strong shock occurred increased with the increase of the angle of internal cone at the lip of the inlet. For an inlet with a central body, the method of characteristics was applied to the design of an internal-channel shape that theoretically results in an efficient recompression in the inlet. It was shown that, if an effuser is connected with the diffuser, a body of revolution with extremely small shock-wave drag can be determined.

On Some Problems Involving Linearization of Aero-Thermodynamical Equations. J. K. L. MacDonald. *Studies and Essays, Presented to R. Courant on His 60th Birthday,* January 8, 1948. New York, Interscience Publishers, Inc., 1948, pp. 241–251. 4 references. $5.50.

The use of Lagrange coordinates to obtain approximations in explicit form of the solutions for some idealized one-dimensional flows that involve heat release. One-dimensional equations for the propagation of waves and flames in a tube which involve dimensionless independent Lagrangian variables are linearized, and explicit approximate solutions are obtained. Comparison of these analytical approximations and numerical integrations based on approximate difference equations that correspond to the nonlinear differential equations of flow shows good agreement between the solutions by the two methods; differences were less than 1.0 per cent.

The Characteristics Method Applied to Stationary Two-Dimensional and Rotationally Symmetrical Gas Flows. F. Pfeiffer and W. Meyer-König. (*ZWB, Forschungsbericht Nr. 1581, March 20, 1942.*) *U.S., N.A.C.A., Technical Memorandum No. 1211 March, 1949.* 20 pp., figs. 6 references.

Busemann's method of characteristics, which was extended by Guderley to two-dimensional and rotationally symmetrical turbulent flows, is developed for still more general cases. By pure mathematics the differential equations for stationary compressible supersonic flows are obtained directly from the differential equations for gas motion. Because of their simple form they may be used for graphic-numerical treatment of special problems.

Ambient Pressure Determination at High Altitudes by Use of Free-Molecule Theory. Bernard Wiener. *U.S., N.A.C.A., Technical Note No. 1821,* March, 1949. 12 pp., diagrs., figs. 8 references.

A method, based on free-molecular theory, for reducing the pressure measurements that are obtained behind an orifice on a rapidly moving object to ambient air pressure. It applies only in that region of the atmosphere in which the mean free path of the air molecules is large with respect to a characteristic body dimension of the object. Results for a sample condition, upon comparison with those computed by the gas-dynamic theory, show the latter method to be inaccurate for altitudes attainable with modern rockets. Ambient pressures calculated by the two methods showed a percentage difference sufficiently large to indicate that the correctness of results depends on the method chosen.

On the Distinction Between Irregular and Systematic Motion in Diffusion Problems. J. M. Burgers. (*Delft, Technische Hoogeschool, Laboratorium voor Aero- en Hydrodynamica, Mededeeling No. 41.*) *Nederlandsche Akademie van Wetenschappen, Verhandelingen,* Vol. 44, No. 4, 1941. 10 pp. (Reprint.) (In English.)

A frequency function is developed to express the number of particles per unit volume in elements of the medium at an initial time and the number in the terminal element at the end of the diffusion, the mean resulting current through an element, the mean resulting velocity of transportation, and the systematic velocity of the particles from a given element at an arbitrary instant. By the use of a method, analogous to that of Fokker and Planck, an equation is obtained without the assumption of "mean free path," separates the systematic motion and the diffusion of the particles, and shows the dependence of the intensity of the diffusion on the magnitude of the mean value of the product of particle velocity and the path length.

On the Influence of the Concentration of a Suspension Upon the Sedimentation Velocity (In Particular for a Suspension of Spherical Particles). J. M. Burgers. (*Delft, Technische Hoogeschool, Laboratorium voor Aero- en Hydrodynamica, Mededeeling No. 42.*) *Nederlandsche Akademie van Vetenschappen, Verhandelingen,* Vols. 44, 45, Nos. 9, 10; 1, 2, 1941–1942. 28 pp. 8 references. (Reprint.) (In English.)

Calculation of the mutual interaction of the fields of flow produced by particles during sedimentation, the rate of sedimentation, and the effective viscosity. Calculations are made for friction effects between particles, walls, and fluid for a suspension of finite area in a field of infinite extent and for friction effects between particles, walls, and fluid confined within a vessel.

On the Shearing Stress in a Viscous Fluid Across a Surface Normal to the Lines of Flow. G. M. Volkoff and D. S. Carter. *American Journal of Physics,* Vol. 17, No. 1, January, 1949, pp. 37–40. 1 reference.

Compression Shocks in Two-Dimensional Gas Flows. A. Busemann. (*Aachen, Technichen Hochschule, Vortrage aus dem-Gebiete der Aerodynamik und Verwandter Gebiete, 1929, pp. 162–169.*) *U.S., N.A.C.A., Technical Memorandum No. 1199,* February, 1949. 17 pp., illus., diagrs., figs. 3 references.

Substituting the velocity axis in one-dimensional static flow-velocity diagrams by a velocity plane, against which static pressure is plotted, gives diagrams with which it is possible to follow two-dimensional flows in cases where compression shocks occur. Examples of a flat plate with a given angle of attack and of a symmetrical flow past a biconvex airfoil and a schlieren record of real flow past such an airfoil demonstrate that the graphical treatment is in close agreement with reality.

A Review of Analytical Methods for the Treatment of Flows With Detached Shocks. Adolf Busemann. *U.S., N.A.C.A., Technical Note No. 1858,* April, 1949. 23 pp., illus., diagrs. 8 references.

On the Theory of the Laval Nozzle. S. V. Falkovich. (*Prikladnaia Matematika i Mekhanika (U.S.S.R.), Vol. 10, No. 4, 1946, pp. 503–512.*) *U.S., N.A.C.A., Technical Memorandum No. 1212,* April, 1949. 16 pp., figs. 4 references.

Flow Pattern in a Converging-Diverging Nozzle. Kl. Oswatitsche and W. Rothstein. (*Munchen, Deutsche Akademie fur Luftfahrtforschung, Jahrbuch I, 1942, pp. 91–102.*) *U.S., N.A.C.A., Technical Memorandum No. 1215,* March, 1949, 42 pp., figs. 4 references.

Calculating the flow pattern near the throat of slender Laval nozzles in both two-dimensional and axially symmetrical flow. It is assumed that the expansion of the gas is adiabatic and the flow stationary. The method is applicable throughout the entire speed range; the velocity of sound itself plays no singular part. The principal weight is placed on the treatment of the flow near the throat of a converging-diverging nozzle. For slender nozzles, formulas are derived for the calculation of the velocity components as a function of the location.

Blade Systems of Circular Arrangement in Steady, Compressible Flow. Hans Reissner. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 307–327. 2 references. $5.50.

By means of the methods of Lorenz, flow patterns with prescribed gradual changes of pressure along stream lines and with a prescribed main component of the velocity vector function are established. The continuity equation, the change of state condition, and the energy equation, referring to a system of coordinates that rotate with the blade system, furnish the remaining two velocity components. The force field follows, then, from the equations of fluid motion. Finally, blade shapes are determined by integrating the differential equations for the stream lines. The procedure furnishes the complete solution of the system of nonlinear equations of flow entirely by quadratures.

Cavitation Characteristics and Infinite-Aspect-Ratio Characteristics of a Hydrofoil Section. J. W. Daily. *American Society of Mechanical Engineers, Transactions*, Vol. 71, No. 3, April, 1949, pp. 269–284, illus., diagrs., figs. 1 reference.

INTERNAL FLOW

A Study of the Supersonic Axial-Flow Compressor. W. A. Loeb. *Journal of Applied Mechanics*, Vol. 16, No. 1, March, 1949, pp. 19–26, figs. 2 references.

Assuming idealized conditions, investigation shows limitations, range, and performance expectations. Good pressure ratios with high efficiencies may be attained. The compressor with a normal shock in the stator is superior to one with normal shock in the rotor. The principal restriction on a compressor with a normal shock in the stator is the Mach Number limitation in the rotor.

Flow Through a Pipe With a Porous Wall. F. C. W. Olson. *Journal of Applied Mechanics*, Vol. 16, No. 1, March, 1949, pp. 53, 54. 4 references.

Differential equations for the pressure drop and flow to determine flow through a pipe with uniformly spaced orifices are derived. Solution is found in terms of elliptic functions.

Nonisothermal Pressure Drop for a Gas. Norman Epstein and John B. Phillips. *Canadian Journal of Research, Section F, Technology*, Vol. 26, No. 12, December, 1948, pp. 503–512, diagr. 18 references.

An equation for calculating the pressure drop accompanying large temperature changes in gas flow is derived from the differential form of the Bernoulli theorem combined with the heat-transfer rate equation. Heating runs were made in the Reynolds Number range 6,000 to 15,000 for air flowing through a single horizontal $^1/_2$ in. standard steel pipe with steam jacket. The pressure drops calculated from the proposed equation agreed closely with the observed experimental values. The method of evaluating pressure drop for turbulent nonisothermal flow by assuming isothermal conditions at a temperature midway between the surface temperature and the mean bulk temperature of the fluid was found to be equally accurate and less cumbersome to use.

STABILITY & CONTROL

Analysis of Wind-Tunnel Stability and Control Tests in Terms of Flying Qualities of Full-Scale Airplanes. Gerald G. Kayten. *U.S., N.A.C.A., Report No. 825*, 1945. 19 pp., figs. 15 references. U.S. Govt. Printing Office, Washington. $0.20.

An aircraft, during a wind-tunnel investigation, should be regarded as an actual flying airplane and not as a scaled-up model. Wind-tunnel tests of powered models can be used to examine the flying qualities of airplanes and to determine the extent to which any particular airplane will satisfy requirements for satisfactory stability, control, and handling characteristics in flight.

Control Reversal Effects on Swept-Back Wings. Haydn Templeton. *The Aeronautical Quarterly* (Royal Aeronautical Society, London), Vol. 1, Part 1, May, 1949, pp. 3–34, diagrs., figs.

A nonmathematical descriptive analysis of aileron reversal effects on sweptback wings and of elevon reversal effects on tailless sweptback wings in which control is exercised by orthodox flaps. The qualitative relation is shown between the structural distortion of the wing and the loss of control power, and, in the case of elevons, the relation between this loss and the effect of wing flexibility.

WINGS & AIRFOILS

Notes on the Linear Theory of Incompressible Flow Round Symmetrical Swept-Back Wings at Zero Lift. F. Ursell. *The Aeronautical Quarterly* (Royal Aeronautical Society, London), Vol. 1, Part 1, May, 1949, pp. 101–122, figs. 4 references.

An integral equation that gives the pressure distribution along the center section of the wing in terms of the profile agrees with Neumark and Küchemann's study in which the correct value of the pressure was obtained by evaluation of the pressure at points off the wing and continuity considerations. The equation can be solved explicitly without Küchemann's numerical process. From a derivation of the linearized equations of motion, Green's theorem on potential functions leads at once to the method of sources whereby the pressure is expressed as a surface integral extended over the wing. For points on the wing, the principal value in some sense of the surface integral must be taken. This requires a line integral that depends on the definition of the principal value. A discontinuity gradient of the wing plan of two cylindrical surfaces joined at an angle to form a sweptback wing has no pronounced effect on the pressure distribution. It is not possible to design wings with kinked isobars in the center unless suction slots or similar devices are used. Although it is possible there may be no wing or only one wing with a given plan form and pressure distribution, there cannot be more than one.

Calculation of Downwash Behind a Supersonic Wing. G. N. Ward. *The Aeronautical Quarterly* (Royal Aeronautical Society, London), Vol. 1, Part 1, May, 1949, pp 35–38. 4 references.

If the solution of the linearized lift problem for a supersonic wing and the disturbance velocity potential at every surface point is known, the complete flow around the wing and the downwash behind the wing may be found. Application of the method is illustrated by a calculation of the downwash far behind a symmetrical flat delta wing at incidence, whose leading edges lie inside the Mach cone from its vertex. The result for this case has been given previously by Robinson and Hunter-Tod. To facilitate comparison of the results, their notation is used.

High-Speed Lift Measurements on a Thick Aerofoil Fitted With a Spoiler. P. J. Wingham. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2319*, March, 1944. 6 pp., figs. 3 references. British Information Services, New York. $0.45.

Measurement of lift coefficient at high speeds of a $27^1/_2$ per cent thick symmetrical airfoil with a spoiler below the lower surface projecting from 0.004 to 0.1 chord, and a fixed spoiler on the upper surface projecting 0.004 chord. Tests over a range of Mach Number 0.4 to 0.755, with incidence variation from plus 4 degrees to minus 4 degrees, showed the general shape of the lift-coefficient incidence curves to be unaltered by variations in spoiler projection. The spoiler altered the zero lift angle and made higher maximum lifts possible, and no stall was produced at high speeds until the spoiler was projected more than 0.09 chord. At the expense of extremely high drags, the spoiler affords a reliable means of high-speed lift control.

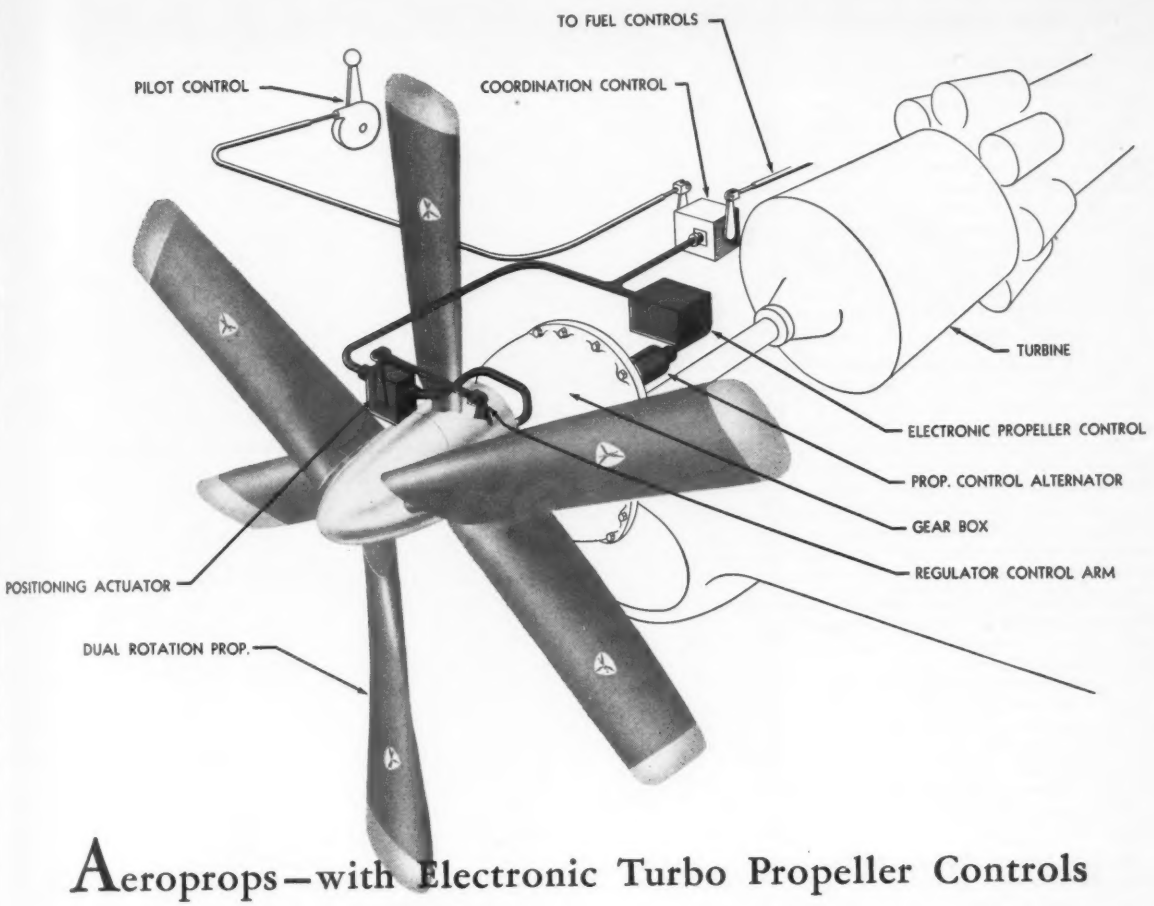
Properties of Low-Aspect-Ratio Pointed Wings at Speeds Below and Above the Speed of Sound. Robert T. Jones. *U.S., N.A.C.A., Report No. 835*, 1946. 5 pp., figs. 7 references. U.S. Govt. Printing Office, Washington. $0.10.

Investigation at Low Speeds of the Effect of Aspect Ratio and Sweep on Rolling Stability Derivatives of Untapered Wings. Alex Goodman and Lewis R. Fisher. *U.S., N.A.C.A., Technical Note No. 1835*, March, 1949. 37 pp., illus., diagrs., figs. 7 references.

Results of tests in rolling-flow in the Langley stability tunnel. Increasing sweepback angle with aspect ratio constant causes large reduction in the damping in roll at low lift coefficients for the higher aspect ratios. For highly swept wings the damping increases in magnitude, and the yawing moment due to rolling changes from negative to positive at moderate lift coefficients. An empirical means of correcting present theory for the effect of tip suction is suggested. A method is developed to account for the effects of the drag on the yawing moment due to rolling throughout the lift range.

Experimental Determination of Pressure Distributions and Transition Lines of Plane Delta Wings at Low Speeds and Zero Yaw. K. Orlik-Ruckemann. *Royal Institute of Technology, Division of Aeronautics, Stockholm, Sweden, Technical Note No. 3*, October 23, 1948. 47 pp., illus., diagrs., figs. 6 references.

Pressure measurements at zero angle of yaw on two plane-delta wings with symmetrical profile, one triangular with aspect ratio 2.50, and the other trapezoidal with aspect ratio 1.34 and taper ratio 0.303. Results are represented by a series of perspective sketches of a semiwing with curves inserted for the pressure distribution in the chordwise direction at all measuring sections and in similar sketches showing curves of the resultant pressure distribution in the spanwise direction. There are also some isobar charts, curves of the local normal force coefficients for chordwise sections and the local center of pressure position as a function of the span, some curves of the local normal force coefficient and the local load coefficient for spanwise cross sections as a function of the relative distance of the section from the trailing edge, and curves of the local and the total normal force coefficient as a function of the angle of attack. The transition lines are determined for four delta wings with no yaw having symmetrical wing profile, three of them triangular with aspect ratio 2.50, 1.67, and 1.00, and one of them trapezoidal with aspect ratio 0.89 and taper ratio 0.303. The results are presented as charts showing the position of the transition line for various angles of attack and Reynolds' Numbers.



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Thin Oblique Airfoils at Supersonic Speed. Robert T. Jones. *U.S., N.A.C.A., Report No. 851,* 1946. 9 pp., figs. 8 references. U.S. Govt. Printing Office, Washington. $0.15.

The methods of thin-airfoil theory extended to sweptback airfoils of finite aspect ratio moving at supersonic speeds for cases of symmetrical airfoils at zero lift which have plan forms bounded by straight lines. Because of the conical form of the elementary flow fields, the results are comparable in simplicity to the results of the two-dimensional thin-airfoil theory for subsonic speeds. In the case of untapered airfoils sweptback behind the Mach cone, the pressure distribution at the center section is similar to that given by the Ackeret theory for a straight airfoil. With increasing distance from the center section, the distribution approaches the form given by the subsonic-flow theory. The pressure drag is concentrated chiefly at the center section and for long wings, a slight negative drag may appear on outboard sections.

The Lift Distribution on Conical and Nonconical Flow Regions of Thin Finite Wings in a Supersonic Stream. Theodore R. Goodman. *Journal of the Aeronautical Sciences,* Vol. 16, No. 6, June, 1949, pp. 365–374, figs. 9 references.

A method is presented for finding the part of the pressure distribution which results in lift on wings in a supersonic stream. The linear theory is employed. The method will solve for flow regions that are conical, as well as those that are not conical. The leading edges may be supersonic or subsonic. When the trailing edges are subsonic, the Kutta condition is shown to be automatically satisfied in one particular case.

Approximate Corrections for the Effects of Compressiblity on the Subsonic Stability Derivatives of Swept Wings. Lewis R. Fisher. *U.S., N.A.C.A., Technical Note No. 1854,* April, 1949. 35 pp., figs. 9 references.

A method which has previously been presented for the estimation of the low-speed stability derivatives of swept wings is modified by means of the Prandtl-Glauert rule to yield approximate corrections for the first-order three-dimensional effects of compressible flow in the subsonic region. Corrections are presented as charts for several aspect ratios and angles of sweep and may be computed simply for other aspect ratios and angles of sweep.

Readers' Forum: Formulas for the Theoretical Lift of Flat Wings at Supersonic Speeds. Ellis Lapin. *Journal of the Aeronautical Sciences,* Vol. 16, No. 6, June, 1949, pp. 381–383, figs.

A Method for Determining the Camber and Twist of a Surface to Support a Given Distribution of Lift, With Applications to the Load Over a Sweptback Wing. Doris Cohen. *U.S., N.A.C.A., Report No. 826,* 1945. 10 pp., diagrs., figs. 6 references. U. S. Govt. Printing Office, Washington. $0.15.

A graphical method consists in replacing the lifting surface and its wake with an equivalent arrangement of vortices and finding the associated vertical velocities. By a division of the vortex pattern into circular strips concentric about the downwash point instead of into the usual rectangular strips, the lifting surface is reduced for each downwash point to an equivalent loaded line for which the induced velocity is readily computed. The ratio of the vertical velocity to the stream velocity is the slope of the surface in the free-stream direction. To illustrate by application, the shape of the wing consistent with the pressure distribution given by the two-dimensional theories has been found for three wings, and it is concluded that the two-dimensional theories are adequate over most of the span of a straight wing but that the more exact treatment is necessary for the tip regions, or if the wing is swept. Application of the method to solve the reverse problem of finding the lift distribution over a given surface indicates a 14 per cent loss in total lift due to the introduction of sweepback with the greatest loss taking place at the center of the span.

Some Theoretical Low-Speed Span Loading Characteristics of Swept Wings in Roll and Sideslip. John D. Bird. *U.S., N.A.C.A., Technical Note No. 1839,* March, 1949. 36 pp., figs. 16 references.

Comparison of experimental results and values obtained by the seven-point method of Weissinger shows its suitability for calculating the span loading in roll, lateral center of pressure, and damping in roll for wings having various aspect ratios, sweep angles, and taper ratios. It also may be used to determine other aerodynamic derivatives of wings which do not require tip suction to be considered. Correction for the first-order effects of compressibility is indicated.

Air Transportation (41)

Markets for Airborne Seafoods. III. Spencer A. Larsen, William Reitz, and Katherine K. Burgum. *Air Transportation,* Vol. 14, No. 4, April, 1949, pp. 47–50, illus.

Shark in the Goldfish Pond? . . . No, King of the Seas! *Interavia,* Vol. 4, No. 2, February, 1949, pp. 71–76, illus. An analysis of the probable effects of the consolidation of American Overseas and Pan American Airways upon U.S. and international civil aviation.

Aircraft and Crew Utilisation. E. T. House. *Aeronautics,* Vol. 20, No. 4, March, 1948, pp. 32–39, figs.

A scheduling control board that displays simultaneously line graphs against time of the operations, delays, and maintenance of all aircraft in order to show factors which determine the number of aircraft required to operate for a given number of services.

Scheduled Air Services in the Soviet Union. *Indian Aviation,* Vol. 33, No. 2, February, 1949, p. 60, illus. Analysis of passenger, mail, and freight schedules of Aeroflot given in an official Russian Travellers' guide for the summer season of 1948.

Realignment of the Domestic Airline Route Pattern. II. Louis E. Black, Jr. *Journal of Air Law and Commerce,* Vol. 16, No. 1, Winter, 1949, pp. 20–39. Summary and critique of C.A.B. decisions.

The Sea-Air Controversy. John H. Frederick. *Distribution Age,* Vol. 48, No. 4, April, 1949, pp. 26, 28, 47, 66, illus.

Internationalization of Air Transport. John C. Cooper. *Air Affairs,* Vol. 2, No. 4, Winter, 1949, pp. 546–560.

Analysis of the stand of the major World Powers on the internationalization of civil aviation. Although the signers of the Chicago Convention for International Civil Aviation, 1944, are in accord in their desire to promote the development of international aviation, they do not agree on the basic political method of international organization of air-transport services. The United States favors continuing to operate under the flags of the separate nations. The United Kingdom, Australia, and New Zealand, on the other hand, favor internationalization.

Evaluation of Proposals to Increase the Warsaw Convention Limit of Passenger Liability. John E. J. Clare. *Journal of Air Law and Commerce,* Vol. 16, No. 1, Winter, 1949, pp. 53–60.

Some Problems Involved in Revision of the Warsaw Convention. K. M. Beaumont. *Journal of Air Law and Commerce,* Vol. 16, No. 1, Winter, 1949, pp. 14–19. Scope of the convention; limitation and basis of carrier liability; charter of flights and negotiability of airway bills.

Economic Aspects; Recovery Year for the U.S. Airlines. Frederick Peters. *Interavia,* Vol. 4, No. 2, February, 1949, pp. 109, 110.

The Haylift. Carl Randall. *The Pegasus,* March, 1949, pp. 1–5, illus. Administration, equipment used, and operational difficulties encountered in the emergency distribution of hay and other feed to snow-stranded livestock on the Nevada-Utah ranges.

South African Airways. *Modern Transport,* Vol. 61, No. 1563, March 12, 1949, p. 10, illus.

Air Line Outlook (1949). Carleton Putnam. *Air Affairs,* Vol. 2, No. 4, Winter, 1949, pp. 491–504.

Jet Liners for Short Range. Sir Frank Whittle. *Flight,* Vol. 55, No. 2094, February 10, 1949, pp. 153–156, illus. (Extended summary of a paper: *London to Paris by Jet Plane.*)

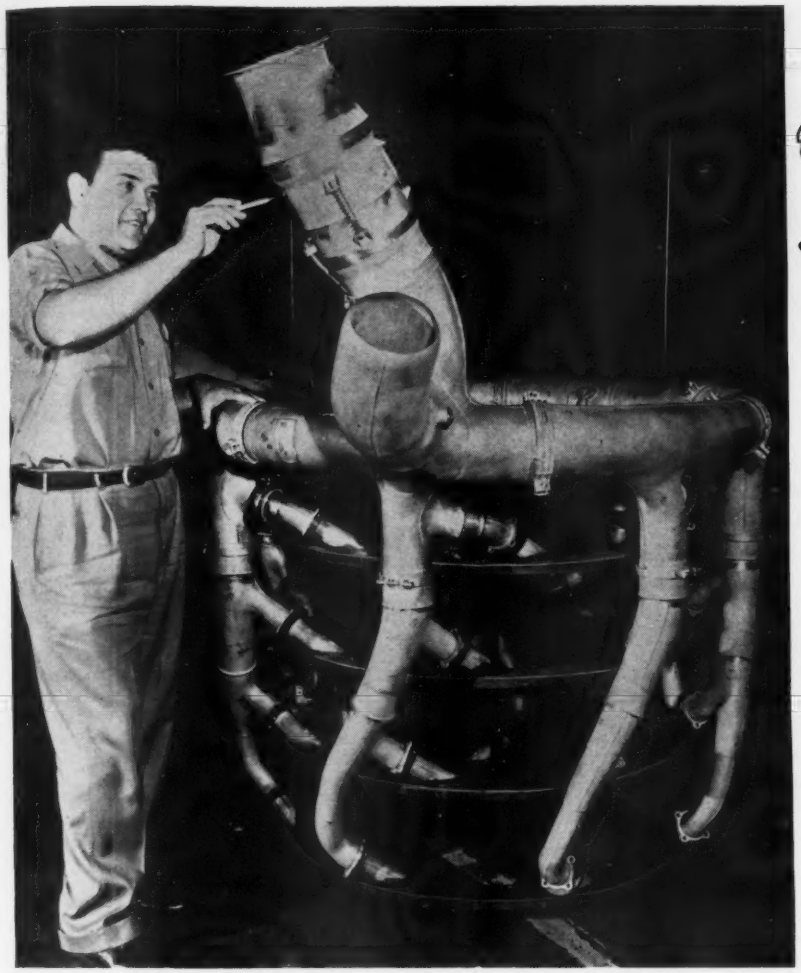
The operating economy of jet transport. Reduced flight time, fuel consumption at an altitude of greatest operating efficiency sufficiently low to permit twice the flight distance that is possible at the same speed at sea level, and the two-thirds reduction of man-power requirements for servicing and maintenance are factors that halve landing costs. A comparison is made between jet- and piston-engined aircraft for performance, weight distribution effects, and cost and revenue analyses.

Surveying by Air; Its Relation to Transport. *Modern Transport,* Vol. 60, No. 1559, February 12, 1949, pp. 13, 14.

Aerial photogrammetry provides a means of topographical surveying to be used in conjunction with other methods. Numerous illustrations are given of the accuracy and economy of such combined efforts.

Aerial Wire Laying. *The Pegasus,* April, 1949, pp. 10–12, 16, illus.

Canadian Aerial Magnetic Surveys (M.A.D.). Ralph Bailey. *Canadian Journal of Research, Section F, Technology,* Vol. 26



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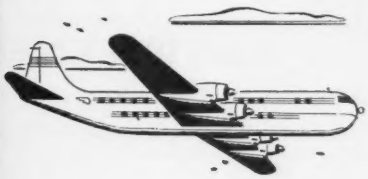

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No. 12, December, 1948, pp. 523–539, illus., diagrs., figs. 5 references.

Tests conducted with an air-borne magnetic detector to measure the earth's total field showed a high degree of accuracy and speed which made the instrument suitable for reconnaissance work over large areas. Inexpensive operation and insensitivity to small local anomalies make this a valuable tool for geophysical prospecting.

Airplane Design & Description (10)

AIRPLANE DESCRIPTIONS

Early Airplane Flights Before the Wrights. John B. Crane. *Air Affairs*, Vol. 2, No. 4, Winter, 1949, pp. 508–522.

Résumé of the British and American flights of powered aircraft, both model and manned, that antedated the first successful powered, man-carrying, three-torque control airplane flight of the Wright Brothers. Two of these flights were made by Americans, Gustav Whitehead at Bridgeport, Conn., circa 1900, and John Hall at Springfield, Conn., circa 1902.

Tankers for Berlin Airlift; Interesting Airtech Installation. *Modern Transport*, Vol. 60, No. 1559, February 12, 1949, p. 12, illus.

Fuel oil transport on the Berlin airlift. Installation by Airtech, Ltd., of 1,800 gal.-capacity tanks in the fuselage of Handley Page Halifax Mark VIII and Halton aircraft increased operational capacity to 1,600 gals.

The Loadmaster 11 (Cancargo Aircraft Manufacturing Co., Ltd.). L. J. Greenlaw and A. J. Wilton. *The Canadian Air Line Pilot*, No. 15, April, 1949, pp. 26–28, illus.

Planes of the Air Navy. *Skyways*, Vol. 8, No. 5, May, 1949, pp. 33–41, illus.

Structure Weight. Norman S. Currey. *Interavia*, Vol. 4, No. 2, February, 1949, pp. 89–92, figs.

Tailless Twins; New Comparative Data on the Two Versions of the A.W. 52 Research Aircraft. *Flight*, Vol. 55, No. 2021, March 31, 1949, p. 369, illus.

"Aero 45" (Czechoslovak) Four-Seater Personal Aircraft. *Interavia*, Vol. 4, No. 3, March, 1949, p. 149, illus.

Armstrong Whitworth Aircraft A.W.52; Data Sheet. *Hawker Siddeley Review*, Vol. 2, No. 1, March, 1949, pp. 25, 26, illus.

Avro 'Anson 20' Trainer; Data Sheet. *Hawker Siddeley Review*, Vol. 2, No. 1, March, 1949, pp. 27, 28, illus.

Pilot Report; New Cessna 170. Don Downie. *Skyways*, Vol. 8, No. 5, May, 1949, pp. 20–22, 49, 57, illus.

New Transcontinental Speed Mark Set by Boeing Stratojet. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 5, March 1, 1949, p. 11, illus. Description and performance of the Boeing XB-47 Stratojet and the Northrop YB-49 Flying Wing.

Boeing 377 "Stratocruiser." *Interavia*, Vol. 4, No. 3, March, 1949, pp. 155–160, illus.

Air Navy's XF7U (Chance Vought). Jerry Leichter. *Skyways*, Vol. 8, No. 5, May, 1949, pp. 16, 17, 54, 55, illus.

The G. A. Cygnet. Stanley Orton Bradshaw. *The Light Plane*, Vol. 2, No. 11, February, 1949, pp. 4–6, illus., diagr.

Super DC-3. *Douglas Aircraft Co., Inc., Engineering Brochure*, February 1, 1949. 28 pp., diagrs., figs. Design and performance specifications of the Super DC-3 and comparison with the unmodified DC-3.

The De Havilland Comet (D.H. 106 Four-Engine Airliner). *Flight*, Vol. 55, No. 2021, March 31, 1949, p. 361, illus.

Impressions of Flying a Fairey "Firefly" Operational Trainer. James Hay Stevens. *Interavia*, Vol. 4, No. 3, March, 1949, pp. 152–154, illus., diagr.

String-Bag—Farewell! *Aeronautics*, Vol. 20, No. 4, March, 1949, pp. 44–47, illus. A narrative of flight experiences with the Fairey Swordfish, which shows the qualities and circumstances that made it outstanding in the recent war.

FIAT G. 46; Two-Seater Trainer. *Interavia*, Vol. 4, No. 3, March, 1949, pp. 164, 165, illus.

Northrop X-4. *Interavia*, Vol. 4, No. 3, March, 1949, pp. 136, 137, illus.

Flying the Stinson (L-5) Sentinel. R. G. Worcester. *The Aeroplane*, Vol. 76, No. 1970, March 11, 1949, pp. 278, 279, illus., diagr.

Significant Vampire Developments. *De Havilland Gazette*, Vol. 4, No. 1, April, 1949, pp. 6, 7, illus. The De Havilland ground-attack fighter, Vampire Mark 1, 3, 5, 6, and 50.

Multum in Parvo; The (Handley Page) Marathon. *Handley Page Bulletin*, Vol. 14, No. 165, November, 1948, pp. 2, 3, 6, illus., diagr.

269 Men on a (Flying) Boat. *The Martin Star*, April, 1949, pp. 10, 11, illus. Seating arrangement in the Martin-built Caroline Mars.

Nallen; Ensi Askelett [The Karhu -48 (Nallen Four-Seat Light Aircraft) Takes the Air.] *Ilmailu*, No. 1, 1949, pp. 6, 7, 31, illus. (English summary.)

The Norseman (V) Has What It Takes. *Canadian Car Journal*, Vol. 6, No. 2, February-March, 1949, p. 6, illus.

Saab Scandia 90 A-2. *Svenska Aeroplan, A B., Stockholm.* 32 pp., illus., diagrs., figs. Design and performance specifications and passenger accommodations.

Ilmailun Koelentäjä. I—Koelentokertomus: (Mráz MIC Sokel.) *Ilmailu*, No. 1, 1949, pp. 18, 19, illus.

Microplanes (XLC-1). *Interavia*, Vol. 4, No. 2, February, 1949, pp. 77, 78, illus. 2 references.

BODY GROUP

Hermes (IV Handley Page)—From the Inside. *Handley Page Bulletin*, Vol. 14, No. 166, December, 1948, pp. 2–6, illus.

CONTROL SYSTEMS

The New Ortho-Kinetic Control. P de Valroger *Aeronautics*, Vol. 20, No. 4, March, 1949, pp. 24–29, diagrs.

A single lever, with three degrees of movement, controls the elevator, rudder, and aileron. It is provided with a central grip for one-hand flying, and mounts a model of the aircraft which corresponds in its attitude to that of the aircraft. When flying blind, the pilot "flies the model" as if he held it in his hands. This technique has proved more instinctive than the method with the horizon bar, and it requires virtually no training. Ortho-kinetic control is suitable for aircraft using the prone position for the pilot. The swing at take-off, caused by the propeller-slipstream, is more difficult to correct with this control than by foot.

Friction in Airplane Control Systems. Ross Hatte. *The Trend in Engineering, University of Washington*, Vol. 1, No. 2, April, 1949, 20–22, diagrs.

Laboratory tests, that duplicated sources of friction, yielded test points which, when plotted on a hodograph, showed reasonably close agreement with the theoretical solid friction curve and provided evidence that the friction in conventional cable-operated airplane control systems is predominantly of the solid type.

PRELIMINARY DESIGN

Estimation of the Effect of a Parameter Change on the Roots of Stability Equations. K. Mitchell. *The Aeronautical Quarterly* (Royal Aeronautical Society, London), Vol. 1, Part 1, May, 1949, pp. 39-58. 9 references.

A rapid and approximate estimation of the effect upon stability of some proposed design in order to produce a desired change in stability. Cowley and Skan's method of solution of polynomial equations, which depends upon the integration of formulas that are obtained from an examination of the rates of change of the roots of a polynomial with respect to its constant term, may be used to estimate the approximate changes in stability due to a small, but not infinitesimal, change in the term. General formulas are applicable to any quartic equation, and special formulas are applicable to the stability of an airplane: The method of use is illustrated by application of the formulas to a calculation of the ateral stability of an airplane, and a check by comparing the predicted approximate change with those calculated by solution of the modified period equations shows that the formulas are reliable, for this typical case.

Bomber Designers Face Range Barriers; Diminishing Returns Seen With Increase of Size and Weight of Craft; Gas Turbine Offers Little Aid. Ivan H. Driggs. *Aviation Week*, Vol. 50, No. 13, March 28, 1949, pp. 21–26, figs.

Naval Fighter Development. Sydney Camm. *Hawker Siddeley Review*, Vol. 2, No. 1, March, 1949, pp. 3–9, illus., diagrs.

Die Entwicklungsmöglichkeiten beim Flugzeubau (The Development Potentialities of Aircraft). P. Schulthess. *Protar*, Vol. 15, No. 1, 2, January-February, 1949, pp. 4, 5.

● A silver streak flashes over the Air Force Base at Muroc, California.

The slim, shark-bellied McDonnell XF-88 is unveiled as another advance in America's air mastery.

XF-88—sleek master of the skies

This twin-jet penetration fighter is capable of operating deep inside enemy territory—acting as an escort for heavy bombers or serving as a dual purpose fighter-bomber.

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The actuators controlling the leading edge and trailing edge flaps on the XF-88 were engineered by Foote Bros. in collaboration with the engineers at McDonnell Aircraft Corporation and the Air Materiel Command. They typify the extremely high precision of gears, actuators and power units made by Foote Bros. for many of the leading aircraft and aircraft engine manufacturers.

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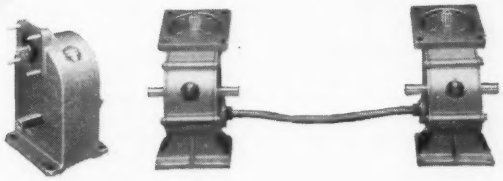

Leading edge and trailing edge wing flap actuators produced by Foote Bros. for the twin-jet McDonnell XF-88.

WINDSHIELDS

Resurfaced Windshield Glass Yields Improved Optical Qualities. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 7, April 1, 1949, p. 14.

Airports & Airways (39)

Aircraft and Runway Design; Interesting Complementary Views Given at Joint Meeting of Civil and Aeronautical Engineers. *Flight*, Vol. 55, No. 2021, March 31, 1949, pp. 383–385, figs. (Extended summary of papers: Aircraft Design with Special Reference to the Restrictions Imposed by Considerations of Airfield Design, by P. H. Watson, The Problem of Airfield Design in Relation to Aircraft Design, C. E. Foster.)

Determination of Runway Lengths for International Civil Aerodromes. Emile Allard. *Interavia*, Vol. 4, No. 3, March, 1949, pp. 143–148, figs.

Vliegbasis (Flight Characteristics). III. G. H. J. Ruijgrok. *De Vliegende Hollander*, Vol. 5, No. 3, March 10, 1949, pp. 55, 56, 58, figs. The modern jet fighter and the I.C.A.O. specifications C 6.

Reflections on Radio (Ekco V.H.F.). *The Light Plane*, Vol. 2, No. 10, January, 1949, p. 2, illus.

System of Air Navigation and Traffic Control Recommended by the Radio Technical Commission for Aeronautics. P. C. Sandretto. *Electrical Communication*, Vol. 26, No. 1, March, 1949, pp. 17–27, diagrs. 11 references.

Westinghouse Type HL High-Intensity Runway Light. *Westinghouse Electric Corporation, Lighting Division, Booklet No. B-4136*, 1948. 8 pp., illus., diagrs.

Construction details, specifications, installation data, and circuit diagram for the Westinghouse HL High-Intensity Runway Light and the Medium Intensity Runway Light.

A Low Cost Boundary Lighting System for Small Airports. M. S. Gilbert. *U.S., Civil Aeronautics Administration, Technical Development Report No. 53*, August, 1947. 12 pp,. illus., diagrs., figs. A two-color gaseous tube boundary lighting system installed at Aretz Airport, Lafayette, Ind.

New Airports (Lima, Buenos Aires, and Montevideo) for South America. *Aviation Week*, Vol. 50, No. 13, March 28, 1949, p. 40, illus.

Aviation Medicine (19)

Evaluation of Aircraft Instrument Displays for Use With the Omni-Directional Radio Range. A. C. Williams, Jr., and S. N. Roscoe. *U.S., Civil Aeronautics Administration, Division of Research, Report No. 84*, March, 1949, 52 pp., figs. 1 reference.

The speed and accuracy with which 48 pilots used mock-ups of eight different VOR aircraft instrument displays to solve typical navigation problems. There were significant time and error differences between displays. Pictorial displays that graphically represent actual spatial relations were superior to symbolic displays, which present information by dial readings, needle deflections, and numbers.

Metric Methods in Binocular Visual Perception. Rudolf Luneburg. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948*. New York, Interscience Publishers, Inc., 1948, pp. 215–240, figs. 3 references. $5.50.

The application of exact mathematical methods to visual space yields mathematical theory of visual perception in which the visual space of binocular vision is a hyperbolic Reimannian space. The theory is confirmed qualitatively by the experimental studies of Hillebrand, Blumenfeld, and Helmholtz.

Response Functions for Types of Vision According to the Müller Theory. Deane B. Judd. *U.S., National Bureau of Standards, Journal of Research*, Vol. 42, No. 1, January, 1949, pp. 1–16, figs. 47 references. Available also as research paper No. RP1946. U.S. Govt. Printing Office, Washington. $0.10.

An analysis as a function of wave length of the chromatic response of persons with normal, deuteranoptic, and protanoptic vision for each of the three primary sensitizing processes that, according to Müller's theory of vision, can be elicited by light stimulus.

Food Requirements in the Arctic Regions. Gottlieb L. Orth. *The Military Surgeon*, Vol. 104, No. 3, March, 1949, pp. 204–206. 4 references.

The difficulty of maintaining a positive water balance in the dry Arctic Regions; behavior changes and food preferences accompanying a liquid imbalance; and the abrupt nature of behavior changes accompanying a marked inefficiency that will develop in one to two days on a moderately deficient diet.

Human Centrifuge in Operation at Aero Medical Laboratory to Determine "g" Tolerances. H. M. Sweeney. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 7, April 1, 1949, pp. 15–23, figs.

Captured German Biophysics Papers Background for Air Force Developments. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 7, April 1, 1949, pp. 7–9, illus.

Tolerance to acceleration wind impact; emergency escape from pressurized cabins at high altitudes with the ejection seat; and a ribbon chute for braking aircraft.

The Development of a Procedure for Evaluating the Proficiency of Air Route Traffic Controllers. John A. Nagay. *U.S., Civil Aeronautics Administration, Division of Research, Report No. 83*, February, 1949 131 pp , figs

Pilots May Soon Be Flying While Lying in Bed. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 5, March 1, 1949, pp. 5, 6, illus.

Some results of human centrifuge tests of the Air Materiel Command prone-position bed. An adjustable construction of nylon netting that is supported over sides which conform to the contours of an average pilot. It enables a toleration of gravity acceleration to 12 *g* for 15 sec.

Comfortization (23)

Factors Affecting the Design of an Air Conditioning and Pressurizing System. P. E. R. Brice. *Aircraft Engineering*, Vol. 21, No. 241, March, 1949, pp. 86–89, 91, figs.

Tudor VIII Cabin Boost; Details of the Marshall (16/40/8) Supercharger Installation. *Flight*, Vol. 55, No. 2021, March 31, 1949, p. 381, illus.

Education & Training (38)

Aids to Training—The Design of Radar Synthetic Training Devices for the R.A.F. G. W. A. Dummer. *Institution of Electrical Engineers, Proceedings*, Vol. 96, Part III (Radio and Communication Engineering), No. 40, March, 1949, pp. 101–116, diagrs., figs. 10 references.

Brief descriptions of the major types of trainers developed concurrently with radar warning, interception, homing, and navigation systems; and the fundamental principles of the control of synthetic targets in two and three dimensions.

Electronics (3)

Study of Simplex Vs. Crossband Operation as Applied to International Aeronautical Air-Ground Communication. *U.S., Radio Technical Commission for Aeronautics, SC34, Paper 45-48/DO-15*, May 14, 1948. 26 pp.

Evaluation of a report submitted by Trans-Canada Air Lines and one submitted by the Swedish Delegation on the comparison of simplex and crossband operation in air-ground communications. The committee recommends simplex operation for en route and emergency communications, crossband for approach and airport control, and either method for airport ground-utility communication.

Comparative Tests of Vertically and Circularly Polarized Airport Traffic Control Transmitting Antennas. S. E. Taggart. *U.S., Civil Aeronautics Administration, Technical Development Report No. 84*, September, 1948. 7 pp., illus., figs.

Determination of Prefabricated Line Lengths for C.A.A. Localizers. S. E. Taggart and V. E. Willey. *U.S., Civil Aeronautics Administration, Technical Development Report No. 59*, December, 1947. 23 pp., illus., diagrs., figs.

Antennas for Circular Polarization. W. Sichak and S. Milazzo. *Electrical Communication*, Vol. 26, No. 1, March, 1949, pp. 40–45, figs. 4 references.

Radio Direction-Finding by the Cyclical Differential Measurement of Phase. C. W. Earp and R. M. Godfrey. *Electrical Communication*, Vol. 26, No. 1, March, 1949, pp. 52–75, diagrs., figs. 7 references. A direction-finding and beacon system in which a reduction of the usual site errors is obtained by the use of

In Jets, too*, there are 36 places where Pesco PRECISION Equipment gives Positive Performance

Positive performance has always been a "must" for aircraft equipment. It's a major reason why Pesco precision fuel and hydraulic products have long been standard equipment on reciprocating engine planes.

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9. Electric Motors for Cabin Heaters (2)
10. Motors for Blowers to Remove Wing Gases (2)
11. Windshield Defroster Blower Motor (1)
12. Engine-driven Hydraulic Pumps (2)
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aerial structures of wide aperture. Ambiguity is resolved by the manner in which the aerials are connected.

A New Solution to the Problem of Vertical Angle-of-Arrival of Radio Waves. E. W. Hamlin, P. A. Seay, and W. E. Gordon. *Journal of Applied Physics*, Vol. 20, No. 3, March, 1949, pp. 248–251, figs. 6 references.

Doppler Radar. Edward J. Barlow. *Institute of Radio Engineers, Proceedings*, Vol. 37, No. 4, April, 1949, pp. 340–355, diagrs., figs. 6 references.

Radar Ignition of Photoflash Lamps. A. W. Randall. *U.S., Civil Aeronautics Administration, Technical Development Report No. 87*, November, 1948. 10 pp., illus.

Feed-Back in Magnetic Amplifiers. I. Alan S. Fitzgerald. *Franklin Institute, Journal*, Vol. 247, No. 3, March, 1949, pp. 223–243, diagrs., figs. 7 references.

The Fundamental Action of Intensifying Screens in Gamma Radiography. E. L. Harrington, H. E. Johns, A. P. Wiles, and C. Garrett. *Canadian Journal of Research, Section F, Technology*, Vol. 26, No. 12, December, 1948, pp. 540–551, diagrs., figs. 1 reference.

Noise Spectrum of a Diode With a Retarding Field. Jacob J. Freeman. *U.S., National Bureau of Standards, Journal of Research*, Vol. 42, No. 1, January, 1952, pp. 75–88, figs. 16 references. Available also as Research Paper No. RP1946. U.S. Govt. Printing Office, Washington. $0.10.

Current Distribution in an Ironless Synchrotron Magnetic Field. Ernest D. Courant. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948*. New York, Interscience Publishers, Inc., 1948, pp. 85–94. $5.50.

Noise-Suppression Characteristics of Pulse-Time Modulations. Sidney Moskowitz and Donald D. Grieg. *Electrical Communication*, Vol. 26, No. 1, March, 1949, pp. 46–51, figs. 7 references.

The Electrical Breakdown Strength of Air at Ultra-High Frequencies. J. A. Pim. *Institution of Electrical Engineers, Proceedings*, Vol. 96, Part III (Radio and Communication Engineering), No. 40, March, 1949, pp. 117–129, diagrs., figs. 16 references.

High-Frequency Absorption Phenomena in Liquids and Solids. Willis Jackson and J. A. Saxton. *Institution of Electrical Engineers, Proceedings*, Vol. 96, Part III (Radio and Communication Engineering), No. 40, March, 1949, pp. 77–80, figs. 17 references.

Phase Lead for A.C. Servo Mechanisms. Arthur H. Benner. *Journal of Applied Physics*, Vol. 20, No. 3, March, 1949, pp. 268–273, figs. 4 references.

Martin's is Electronics Leader. John M. Pearce. *The Martin Star*, April, 1949, pp. 7–9, illus.

Engineering Practices (49)

Electronic Digital Counters. Warren H. Bliss. *Electrical Engineering*, Vol. 68, No. 4, April, 1949, pp. 309–314, diagrs., figs. 5 references.

On Probability Problems in the Theory of Counters. W. Feller. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948*. New York, Interscience Publishers, Inc., 1948, pp. 105–115. 8 references. $5.50.

Developments in the Useful Circular Nomogram. Douglas P. Adams and Howard T. Evans, Jr. *Review of Scientific Instruments*, Vol. 20, No. 3, March, 1949, pp. 150–159 figs. 1 reference.

A Storage System for Use With Binary-Digital Computing Machines. F. C. Williams and T. Kilburn. *Institution of Electrical Engineers, Proceedings*, Vol. 96, Part III (Radio and Communication Engineering), No. 40, March, 1949, pp. 81–100, diagrs., figs. 11 references.

The requirement for digital computing machines of large storage capacity has led to the development of a storage system in which the digits are represented by a charge pattern on the screen of a cathode-ray tube. Initial tests have been confined to commercial tubes. Short-term memory of the order of 0.2 sec. is provided by the insulating properties of the screen material. Long-term memory is obtained by regenerating the charge pattern at a frequency greater than 5 cycles per sec. The regeneration makes accurate stabilization of the position of the charge pattern on the tube unnecessary. If such a machine were operated in the series mode with this storage system, an instruction would be set up and obeyed in 600 μ sec.

Equipment

ELECTRICAL (16)

Safety in Aircraft Electric Systems. Morton H. Adolphe. *Electrical Engineering*, Vol. 68, No. 3, March, 1949, pp. 227–229, illus. 4 references.

Potentially, fatal electrical hazards are multiplied by the use of 120-volt d.c. and 120/208-volt a.c. systems. Engineering department reference manuals should include an explanation of these dangers and should indicate in detail design standards for their elimination. Instruction of all aircraft service personnel in safe working techniques will foster respect for high voltages. Some prevalent shortcomings in present practice include misjudging the current-carrying capacity of a wire and the installation of equipment not intended for high-voltage operation.

Armature Windings and Their Tests. R. D. Searle. *The Technical Instructor*, Vol. 4, No. 3, March, 1949, pp. 3–10, figs.

HYDRAULIC & PNEUMATIC (20)

Pneumatic Relays; Types and Operating Characteristics. James L. Dooley. *Machine Design*, Vol. 21, No. 4, April, 1949, pp. 109–115, diagrs., figs.

Which Hydraulic Pump?; Comparison of Features of Basic Types of Hydraulic Pumps Aid in Selection to Fit the Job. *Machine Design*, Vol. 21, No. 4, April, 1949, pp. 141–148, illus., diagrs.

Performance Criteria for Positive-Displacement Pumps and Fluid Motors. W. E. Wilson. *American Society of Mechanical Engineers, Transactions*, Vol. 71, No. 2, February, 1949, pp. 115–120, figs. 4 references.

Fluid Pressure Boosters. Frank Flick. *Product Engineering*, Vol. 20, No. 4, April, 1949, pp. 115–119, illus., diagrs.

Recommended circuits and application of air and oil operated boosters that produce fluid pressures greater than 2,000 lb. per sq. in.

Aeroquip Aircraft Catalog No. 200. *Aeroquip Corporation*, Jackson, Mich., 1949. 52 pp., illus., diagrs., figs.

Flight Operating Problems (31)

ICE PREVENTION & REMOVAL

An Investigation of a Thermal Ice-Prevention System for a Twin-Engine Transport Airplane. Alun R. Jones *U.S., N.A.C.A., Report No. 862*, 1946. 37 pp., illus., diagrs., figs. 23 references. U.S. Govt. Printing Office, Washington. $0.25.

REFUELING IN FLIGHT

Mid-Air Refueling Proves Practical in Globe-Girdling B-50 Flight. R. G. Naugle. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 7, April 1, 1949, pp. 5, 6 illus.

PILOTING TECHNIQUE

The Technique of Taxying. *The Light Plane*, Vol. 2, No. 11, February, 1949, pp. 9, 10, illus.

Flight Safety & Rescue (15)

An Analysis of Personal Airplane Power Plant Failures During 1947 With Some Suggested Remedies. Fred E. Weick. *The Texas Agricultural & Mechanical College System, Texas Engineering Experiment Station, Research Report No. 4*, December, 1948. 15 pp.

Various types of power plant failure include engine structure, fuel system, ignition system, propeller, lubricating system, accessories, and control system. They show that two-thirds of the recorded accidents and seven-eighths of these of known cause, were attributable to failure of the fuel system. Remedies are: duplication of system, change in basic method to eliminate the item giving trouble; use of a fuel system giving unmistakable warning when one hour of fuel is left, and accurate indication of fuel quantity from that time on; improvement in detail design, in construction, and in maintenance.

Pilot Safety. *Naval Aviation News*, No. 24, April, 1949, pp. 1–6, illus.

This portable 500-amp aircraft energizer was developed a few months ago by General Electric engineers to furnish commercial and military air bases with a convenient 28½-volt ground power supply. The heavy-duty power source provides plenty of amps for starting jet and reciprocating engines, for pre-flight check of the aircraft's electrical system, for production tests in shop and hangar repair areas.

Mounted on wheels, the energizer can be furnished with either gasoline-engine drive mounted in a trailer (as in the photograph) or a-c motor drive mounted on a two-wheel dolly. The basic generator and control system is available also for "Jeep" mounting. The mobility of the unit permits faster takeoffs as well as strategic dispersal of aircraft during hostilities.

This power supply is one of many products manufactured by General Electric for the aviation industry. G-E engineers are continually at work designing new and better products to increase efficiency and cut operating costs. Get complete information on our aviation products from your nearest G-E representative. *Apparatus Department, General Electric Company, Schenectady 5, N. Y.*

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GENERAL ELECTRIC

822-3

Procedure in Safety Enforcement Proceedings With Respect to Airman Certificates; The Evolution of an Administrative Procedure. Merrill Armour and Harley G. Moorhead, Jr. *Journal of Air Law and Commerce*, Vol. 16, No. 1, Winter, 1949, pp. 40–52.

Flight Testing (13)

Determination of Drag of Jet-Propelled Aircraft in Flight. G. W. Trevelyan and D. R. Blundell. *The Aeronautical Quarterly* (Royal Aeronautical Society, London), Vol. 1, Part 1, May, 1949, pp. 89–100, diagrs., figs.

The drag (at low Mach Numbers) has been determined directly from flight tests under conditions when the engine thrust is an unimportant factor. It appears that the deceleration method is better and more accurate than the glide method. The drag obtained by this method is with small mass flow through the engine. With greater mass flow there may be differences in the external flow over the intakes, and allowances may have to be made in applying these results to conditions of high thrust.

Note on Propeller-Turbine Reduction Methods. E. C. Pike. *The Aeronautical Quarterly* (Royal Aeronautical Society, London), Vol. 1, Part 1, May, 1949, pp. 77–88, figs. 2 references.

The reduction to standard conditions of the performance of turboprop aircraft is more difficult than that of the turbojet because of a third variable in the engine performance equations. A "nondimensional" graphical method that is adequate for turbojet reduction, therefore, is awkward from the flight-test and other points of view. Also there is little information on the presence of other variables such as variation of combustion efficiency with pressure, alteration of the calorific value of the fuel, and viscosity effects. There are three possible ways of reducing turboprop performance to standard conditions: a "nondimensional" graphical method with an extra variable in which the relations between the variables are established during the test; and two derivative methods in which variation is established previously by test, or is assumed from firms' estimates. Of these, the graphical method is simplest.

Studying the Flying Qualities. I, II. Hans Bruckner. *Interavia*, Vol. 4, Nos. 2, 3, February–March, 1949, pp. 97, 98; 150, 151, figs. 2 references.

Basic flight tests, with the usual air-borne instruments, provide numerical data on controllability and stability sufficient for a preliminary safety guarantee. The measured flight test uses additional equipment to automatically record pressures, velocities, and control forces as graphs.

Instrumentation for Flight Testing the XB-45 Airplane. D. K. Warner. *Instruments*, Vol. 22, No. 4, April, 1949, pp. 314–317, illus., diagr.

Nomogram—Flight-Test Reduction. H. M. Cameron and H. H. Miller. *Aero Digest*, Vol. 58, No. 3, March, 1949, pp. 111, 112, fig.

Fuels & Lubricants (12)

Control of Foaming by Adding Known Mixtures of Pure Chemicals. J. W. McBain, Sydney Ross, A. P. Brady, and R. B. Dean. *U.S., N.A.C.A., Technical Note No. 1842*, April, 1949. 12 pp., tables. 3 references.

The method of testing foam volume at room temperature, the bubbling method at high temperatures (100° and 140°C.), and the beating and evacuation method were used to test 13 substitutes for glycerol and 27 substitutes for Aerosol OT for defoaming ability at 140°C. on Aeroshell 120 oil. In a ratio of 4 parts glycerol (or substitute) to 1 part Aerosol OT (or substitute) at concentrations of 1,000 to 1,500 parts per million, the best of these emulsions completely inhibited foaming. The best concentration was sorbitol and Aerosol OT, 800 and 200 parts per million, respectively. This concentration was an excellent defoamer for 4 hours but left a sticky residue.

Attempts to Defoam Existing Oils by Processing. J. W. McBean, J. V. Robinson, W. W. Woods, and I. M. Abrams. *U.S., N.A.C.A., Technical Note No. 1845*, April, 1949. 26 pp., figs. 1 reference.

Lubricating oil has been processed by treatment with various absorbents and by solvent extraction in an attempt to reduce foaming. Activated magnesium oxide, silica gel, and Porocel, when packed in columns through which Aeroshell was recycled, defoamed the oil somewhat, but not to such an extent as did charcoal. Extraction of lubricating oils with liquid sulfur dioxide, phenol, and aqueous sodium hydroxide failed to produce any significant change in foaming. Finely divided sodium chloride, dispersed into the oil and then removed by filtration, had no effect on the foam stability.

Combustion Studies Using the Golay Photothermal Detector With an Infrared Monochromator. J. T. Agnew. *American Society of Mechanical Engineers, Transactions*, Vol. 71, No. 2, February, 1949, pp. 107–114, illus., diagrs., figs. 7 references.

Diffusion Flames. Kurt Wohl, Carl Gazey, Jr., and Numer M. Kapp. *University of Delaware, Newark, Del., Engineering Experiment Station, Bulletin No. 1*, October, 1948. 41 pp., illus., figs., tables. 5 references. $0.75.

The height of flames from pure city gas, butane, and from a mixture by volume of 50 per cent city gas and butane, in both laminar and turbulent flow show the effects of various combinations of an increase in the volume rate flow, the tube diameter and Reynolds Number, and the effect of the square root of fuel flow rates. The theoretical calculations of Burke and Schumann for low-velocity flows extended with fair agreement, but with less complex equations, to high velocity flows. Flame structure was recorded by direct and shadow photography. The diffusion of gaseous fuel into air, assumed by Burke and Schumann, does not occur. The change from turbulent flow in the tube to laminar outside the tube, characteristic of both city gas and butane laminar-flow flames, is the result of a gradual increase in viscosity that is caused by the formation of products of combustion and by the rise in temperature that produces the laminar flow of unburnt gas inside the cylindrical burning zone of the diffusion flame. As viscosity increases, an approximate expression for the flame height reaches a value proportional to the square root of the flow rate of the pure gas alone. For turbulent flows, flame heights are proportional to the tube diameter and roughly independent of velocity. The absolute values of molecular diffusivity, burning velocity, and eddy diffusivity, of turbulent flows, are calculated from the coefficients of the empirical equations for flame height, and have reasonable orders of magnitude.

Non-Flammable Hydraulic Fluids. C. C. Singleterry, E. M. Glass, and others. *S.A.E. Annual Meeting, Detroit*, January 10–14, 1949, Preprint. 14 pp.

No Fuel—No Aviation. *Interavia*, Vol. 4, No. 3, March, 1949, pp. 127–131, illus.

Gliders (35)

Motorless Flight; Better Performance With Tailless Sailplanes. Walter M. Horten. *Interavia*, Vol. 4, No. 2, February, 1949, pp. 104–107, illus., diagrs., fig.

Compared with conventional gliders of the same span and wing loading, the tailless design has a lighter weight and a higher aspect ratio that reduces sinking speed and lowers the drag, thus improving the L/D ratio at high speeds. Dimensions, weights, and performance are given for the high-speed Horten IV and VI.

The Castel Mauboussin C.M.7. Sailplane. *Sailplane and Glider*, Vol. 17, No. 3, March, 1949, p. 51, fig.

The WLM—I; A Swiss High Performance Sailplane Made by the Luzern Firm of Weber-Landolf-München. *Sailplane and Glider*, Vol. 17, No. 3, March, 1949, pp. 55–58, illus., diagr., fig.

Swiss International (Soaring Competition, 1948). Rene Comte. *Soaring*, Vol. 13, Nos. 3, 4, March–April, 1949, pp. 2, 3, 9–11, illus., fig.

Technical Progress; (A Survey). August Raspet. *Soaring*, Vol. 13, Nos. 3, 4, March–April, 1949, pp. 4, 5, 7, illus. 23 references.

Soaring in France; The La Tour du Pin Aero Club. Guy Borge. *Sailplane and Glider*, Vol. 17, No. 3, March, 1949, pp. 50, 51, illus.

Guided Missiles (1)

Aerodynamic Pursuit Curves for Overhead Attacks. G. H. Handelman. *Franklin Institute, Journal*, Vol. 247, No. 3, March, 1949, pp. 205–221, figs. 6 references.

The determination of the proper deflection which the gunner in a bomber should make for defense against overhead fighter attack during the bombing run, necessitates study of the pursuit curve followed by the fighter. The major qualitative results obtained by graphically integrating the differential equations of the aerodynamic pursuit curves and the pure pursuit curves show that the changes in air speed occurring along an aerodynamic pursuit

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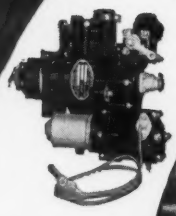

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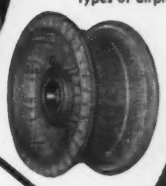

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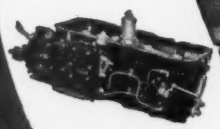

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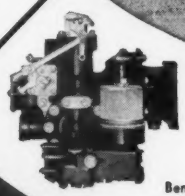

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Development of Spoiler Controls for Remote Control of Flying Missiles. G. Ernst and M. Kramer. (*ZWB Forschungsbericht Nr. 1717, January 6, 1943.*) *U.S., N.A.C.A., Technical Memorandum No. 1210*, March, 1949. 42 pp., illus., diagrs., figs. 12 references.

Guided Missiles Span New Horizons. Sam B. Beaudry. *Ryan Reporter*, Vol. 1, No. 2, February, 1949, pp. 2, 3, 14–16, illus. Brief résumé of the power plants, control systems, and the types of missiles that have been developed.

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GEARS & CAMS

Modification and Uses for Basic Types of Cams. Edward Rahn. *Product Engineering*, Vol. 20, No.4, April, 1949, pp. 120–121, diagrs., figs.

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Boeing Service Guide, No. 18, March, 1949. 10 pp., illus., diagrs.

Contents: Stratocruiser Air Induction System. Main Gear Manual Operation Precautions. Heater Operation Precautions. R-4360 Engine Oil Sump Hose Clamp Installation.

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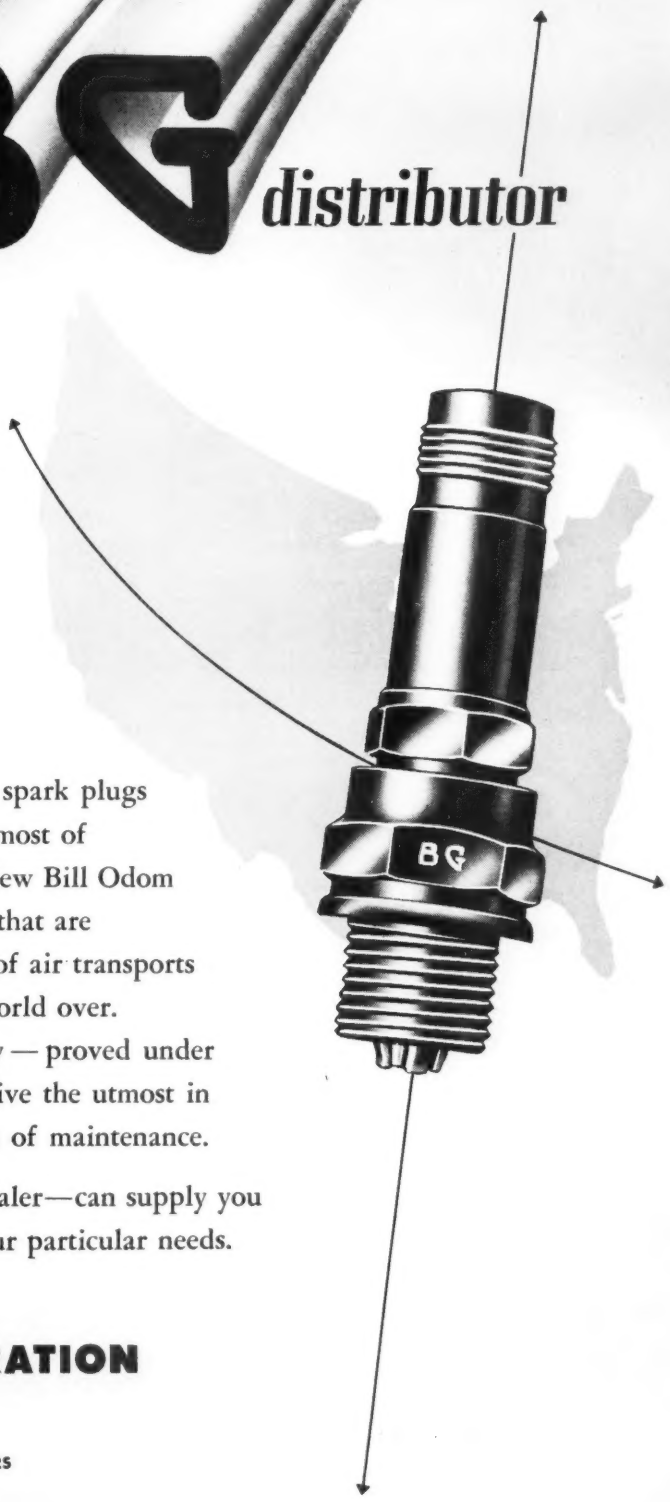

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Materials (8)

METALS & ALLOYS

Tension Properties of Aluminum Alloys in the Presence of Stress-Raisers. I—Effects of Triaxial Stress States on the Fracturing Characteristics of 24S-T Aluminum Alloy. A. W. Dana, E. L. Aul, and G. Sachs. *U.S., N.A.C.A., Technical Note No. 1830*, March, 1949. 55 pp., illus., figs. 17 references.

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A Nickel-Aluminum-Molybdenum Creep Resistant Alloy. H. V. Kinsey and M. T. Stewart. *Canadian Journal of Research, Section F, Technology*, Vol. 27, No. 2, February, 1949, pp. 80–98, figs. 4 references.

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Low Temperature Properties of the Austenitic Stainless Steels. R. H. Henke. *Product Engineering*, Vol. 20, No. 4, April, 1949, pp. 104–107, figs. 7 references.

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Discontinuous Solutions in the Theory of Plasticity. W. Prager. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 289–300, figs. 14 references. $5.50.

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Modifications in procedures for the evaluation of ceramics and ceramic-metal materials include: the incorporation of a soak of 100°F. over-temperature under a load of 1,000 lbs-per sq. in. in the tensile evaluation and the provision of a helium atmosphere around the specimen grips and at the specimen proper to offset oxidation of the ceramics; a three-point loading system that minimizes the effect of flaws and determines a truer potentiality of the material; and the addition of a Globar furnace to thermal-shock apparatus. In the work on ceramels, difficulty is encountered with carbides because, not only do the metals tend to oxidize, but the carbides tend to be converted to oxide, some so rapidly that they are unsuitable for any use. It is noted by x-ray diffraction work, somewhat tentatively, that the metal in the oxides and carbides goes into solid solution in very great amounts, the extent of which is being determined by means of micro-hardness checks for a hardness gradient between the ceramic and metal portions.

Dutch Report on Visit to I. G. Farbenindustrie, Leverkusen Synthetic Rubber and Allied Subjects. J. C. Derksen, R. Houwink, and others. *Gt. Brit., British Intelligence Objectives Sub-Committee, Miscellaneous Report No. 84*, 1947. 47 pp., diagrs., figs. British Information Services, New York. $1.45.

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Further Properties of Photoelastic Fosterite at Elevated Temperatures. M. M. Leven. *Society for Experimental Stress Analysis, Proceedings*, Vol. 6, No. 2, 1948, pp. 106–110, figs. 1 reference.

The Response of Certain Inorganic Phosphors to Far Ultraviolet Radiation. D. H. Tomboulian and E. M. Pell. *Journal of Applied Physics*, Vol. 20, No. 3, March, 1949, pp. 263–267, figs. 7 references.

Laminating of Structural Wood Products by Gluing. A. C. Knauss and M. L. Selbo. *U.S., Forest Products Laboratory, Madison, Wis., Report No. D1635*, Revised October, 1948. 116 pp., illus., diagrs., figs. 15 references.

Animal Glues: Their Manufacture, Testing, and Preparation. *U.S., Forest Products Laboratory, Madison, Wis., Report No. D492*, Revised December, 1948. 11 pp. 13 references.

Drying and Conditioning Glued Joints. *U.S., Forest Products Laboratory, Madison, Wis., Report No. D475*, Revised August, 1948. 7 pp., tables.

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SANDWICH MATERIALS

Small Bending and Stretching of Sandwich-Type Shells. Eric Reissner. *U.S., N.A.C.A., Technical Note No. 1832*, March, 1949. 89 pp., figs. 10 references.

A system of basic equations for the analysis of small deflection problems of sandwich-type thin shells which reduces to Love's theory of thin shells when the transverse shear and normal stress deformability of the core of the sandwich is of negligible importance. The system of basic equations has been applied to a number of specific problems from the theory of plates, circular rings, circular cylindrical shells, and spherical shells, and it has been found that the effects of both transverse shear and transverse normal stress deformation may be of such magnitude that an analysis which disregards them gives values for deflections and stresses which are appreciably in error.

Comparative Strengths of Some Adhesive-Adherend Systems. N. J. DeLollis, Nancy Rucker, and J. E. Wier. *U.S., N.A.C.A., Technical Note No. 1863*, March, 1949. 43 pp., illus., figs. 17 references.

Combinations of adhesives and adherends were studied to determine double-lap shear, tensile, long-time loading shear, and impact strengths. Adhesives were polyvinyl acetate, cellulose nitrate, resorcinal resin, casein, gum arabic, natural rubber, and neoprene. Adherends were stainless steel, aluminum alloy, paper-phenolic laminate, glass, birch wood, and hard rubber.

Methods for Conducting Mechanical Tests of Sandwich Construction at Normal Temperatures. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1556*, Revised, October, 1948. 35 pp., illus., diagrs. 1 reference.

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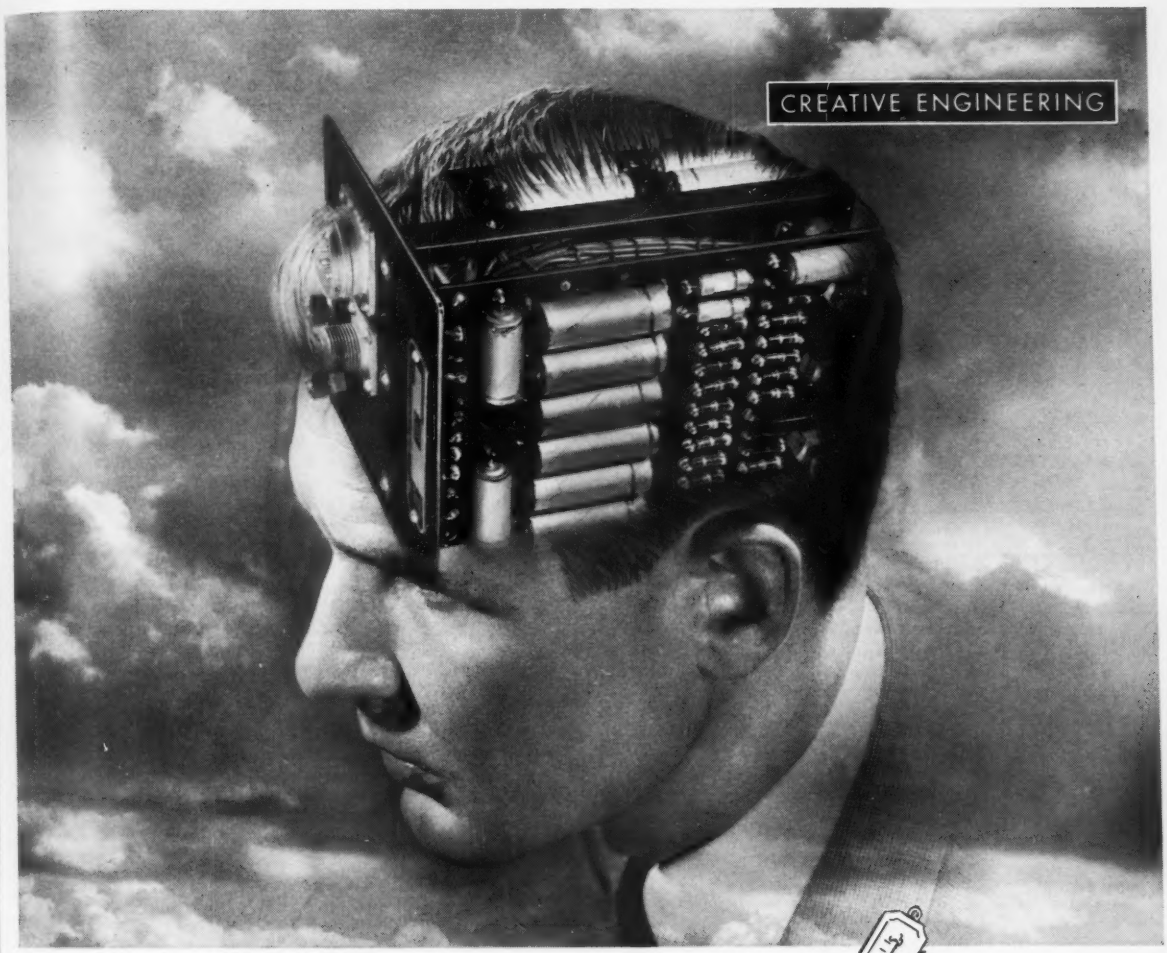

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JET & TURBINE (5)

Experimental and Theoretical Studies of Surging in Continuous-Flow Compressors. Robert O. Bullock, Ward W. Wilcox, and Jason J. Moses. *U.S., N.A.C.A., Report No. 861*, 1946. 13 pp., illus., diagrs., figs. 8 references. U.S. Govt. Printing Office, Washington. $0.15.

Data obtained from instrument recordings of the magnitude and frequency of pressure pulsations during surging and from experimental studies of the transition from steady to surging flow, the phase relation of static, total and velocity pressures during surging, the effect of changes in the volume of the compressor system and impeller tip speed on the frequency, and the magnitude of the pulsations usually showed a transition region characterized by erratic pulsations of small magnitude to exist between the region of stable operation and the point where definite surging begins. The uniformity of the pulsation frequency throughout the system indicated that the system surged as a unit. Although the pressure pulsations were periodic, their variations with respect to time were frequently nonsinusoidal. Decreasing the volumetric capacity of the external pipes increased the frequency and decreased the amplitude. Both depended on a complex relation of the capacity and the resistance of each component of the system. If, as it appears, surging is a manifestation of an instability of flow in a compressor, the compressor characteristic curve must be positive and a time interval must exist between a change in flow conditions within the compressor and the static-pressure adjustment in the external pipes. Therefore, the surge-free range of any compressor could be extended or the magnitude of the surging pulsations could be reduced either by reducing the magnitude of the positive slope of the characteristic curve or by changing the volumetric capacity of the compressor components.

Laboratory Evaluation of a Method Proposed by Gnam for Measuring the Temperature of Rotating Parts. Andrew I. Dahl and Paul D. Freeze. *U.S., National Bureau of Standards, Journal of Research*, Vol. 41, No. 6, December, 1948, pp. 601–607, illus., diagrs., figs. Available also as Research Paper No. RP1942. U.S. Govt. Printing Office, Washington. $0.10.

A rotating circuit, consisting of a thermocouple in series with the rotor coils of a converter, and a stationary circuit, consisting of the stator coils of the converter and a transformer, are linked magnetically. One thermocouple junction is fixed to the rotating part whose temperature is to be measured, and the other protrudes from a hollow shaft into a furnace. The temperature of the rotating part is indicated by the e.m.f. of the stationary circuit in which an oscilloscope is used as a null indicator.

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Comparison Between Predicted and Observed Performance of Gas-Turbine Stator Blade Designed for Free-Vortex Flow. M. C. Huppert and Charles MacGregor. *U.S., N.A.C.A., Technical Note No. 1810*, April, 1949. 55 pp., diagrs., figs. 7 references.

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Jets for Light Aircraft. *The Light Plane*, Vol. 2, No. 11, February, 1949, pp. 11, 12, diagr.

New Jet Engine Test Cell. *Ryan Reporter*, Vol. 1, No. 2, February, 1949, p. 13, illus. Design features of the Ryan Aeronautical Company's jet-engine test cell.

RECIPROCATING (6)

The Beech Twin-Quad Power Plant. J. W. Massey. *Aeronautical Engineering Review*, Vol. 8 No. 6, June, 1949, pp. 30–36, illus., diagrs.

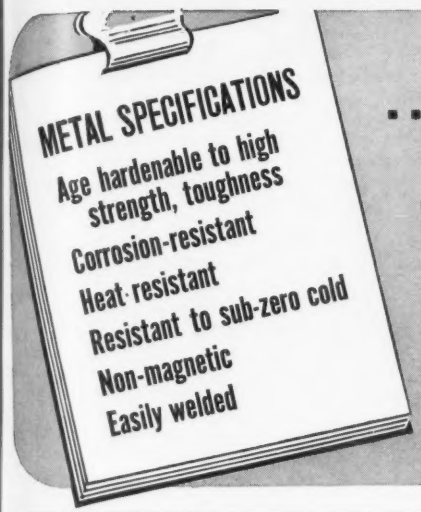
Twin units of two horizontally opposed engines that are completely submerged inside the wing give higher performance than the conventional four-engined airplane of the same gross weight and power; especially for the one-engined-inoperative condition. An inoperative engine is automatically disengaged from the propeller main gearbox by a multiple-disc clutch in which spiral splines separate the clutch discs and allow disengagement without affecting the propeller or the other engine. The efficiency of a unit after disengagement of one engine is increased so that more than three-engine thrust is provided. Identity of the inoperative engine is indicated positively by zero tachometer and oil-pressure readings. The need for feathering the propeller is eliminated. If the engine restarts, the torque will automatically cause re-engagement of the engine.

Cylinder-Temperature Correlation of a Single-Cylinder Liquid-Cooled Engine. Benjamin Pinkel, Eugene J. Manganiello, and Everett Bernardo. *U.S., N.A.C.A., Report No. 853*, 1946. 15 pp., figs. 7 references. U.S. Govt. Printing Office, Washington. $0.15.

An analysis based on nonboiling forced-convection heat-transfer theory. Semiempirical expressions, for the average head and barrel temperatures, are derived as functions of the engine conditions and temperature, the flow rate, and the physical properties of the coolant. The physical properties of the coolant that appear in this equation are the thermal conductivity and specific heat, and the viscosity. In the region of operation where forced convection is the controlling cooling phenomenon, correlation of the cooling performance of various coolants on the basis of these coolant physical properties can be expected. The correlation equation developed will be inaccurate where appreciable boiling of the coolant occurs on the engine walls.

Analysis of Cooling Limitations and Effect of Engine-Cooling Improvements on Level-Flight Cruising Performance of Four-Engine Heavy Bomber. Frank E. Marble, Mahlon A. Miller, and E. Barton Bell. *U.S., N.A.C.A., Report No. 860*, 1946. 13 pp., diagrs., figs. 10 references. U.S. Govt. Printing Office, Washington. $0.15.

A comparison of performance of an airplane with a standard engine and an airplane with an engine modified by an injection impeller and ducted head baffles, in order to improve its cooling characteristics, showed that the maximum specific range increased as much as 38 per cent for operation where wide cowl-



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	ROD AND BAR					
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Cu 29.0	Heat treated	140-160	100-120	30-20	265-300	40
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Fe 0.9	Heat treated	140-170	100-130	30-15	265-320	26

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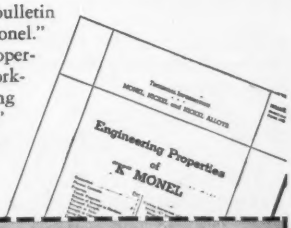

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Analysis of Spark-Ignition Engine Knock as Seen in Photographs Taken at 200,000 Frames Per Second. Cearcy D. Miller, H. Lowell Olsen, Walter O. Logan, Jr., and Gordon E. Osterstrom. *U.S., N.A.C.A., Report No. 857*, 1946. 11 pp., diagrs., figs. 26 references. U.S. Govt. Printing Office, Washington. $0.15.

The type of knock in the spark-ignition engine, which involves violent gas vibration, originates as a self-propagating disturbance starting at a point in the burning or autoigniting gases and spreading out from that point through the incompletely burned gases at a rate as high as 6,800 ft. per sec., which is about twice the speed of sound in the burned gases. Apparent formation of free carbon particles in both the burning and the burned gas is observed within 10 microsec. after the passage of the knock disturbance through the gases.

Improved Techniques in the Study of Engine Firing Orders Using the Vectorscope. G. J. Dashefsky. *American Society of Mechanical Engineers, Transactions*, Vol. 71, No. 3, April, 1949, pp. 235–244, illus., diagrs., figs.

Manufacturing the Alvis Leonides. James Hay Stevens. *Aircraft Engineering*, Vol. 21, No. 241, March, 1949, pp. 76–84, illus., diagrs., figs.

Analysis of Altitude Compensation Systems for Aircraft Carburetors. Edward W. Otto. *U.S., N.A.C.A., Technical Note No. 1874*, May, 1949. 38 pp., diagrs., fig. 1 reference.

Pratt & Whitney "Twin Wasp E." *Aero Digest*, Vol. 58, No. 3, March, 1949, p. 114, illus., diagrs.

Ryan Manifolds—Up Front Since 1927. *Ryan Reporter*, Vol. 1, No. 2, February, 1949, p. 8, illus.

ROCKET (4)

Some Observations on the Problems of Rocket-Motor Cooling Design. J. L. B. Selwood. *American Rocket Society, Journal*, No. 76, March, 1949, pp. 16–26, diagrs., figs. 6 references.

The Prospects of Jet-Reaction Flight. I. Eugen Saenger. *American Rocket Society, Journal*, No. 76, March, 1949, pp. 27–41, diagrs., figs.

Production (36)

Building the (Fairchild Packet) C-119. *The Pegasus*, April, 1949, pp. 1–6, 8, 9, illus., diagrs. Manufacture planned to allow expansion of current low-volume production.

Building the Brabazon. *The Aeroplane*, Vol. 76, No. 1970, March 11, 1949, pp. 275–277, illus. Pictorial summary of the various stages in the construction of the Brabazon.

It's Moving Day. *Ryan Reporter*, Vol. 1, No. 2, February, 1949, pp. 6, 7, 13, illus. The roll of plant engineering in the Ryan Aeronautical Company's aircraft production.

Electric Spot-Welding of Pressed Sheet Parts in the Serial Manufacture of the Secan "Courlis" Personal Aircraft. G. Bruner. *Interavia*, Vol. 4, No. 2, February, 1949, pp. 93–96, illus., diagrs.

Propellers (11)

The Influence of Blade-Width Distribution on Propeller Characteristics. Elliott G. Reid. *U.S., N.A.C.A., Technical Note No. 1834*, March, 1949. 141 pp., illus., figs., tables. 14 references.

Force and wake survey tests on a three-blade model propeller characterized by equal activity factors and dissimilar blade-plan forms showed that although their efficiency envelopes differed inconsequentially, it was found that blades tapered from broad roots to narrow tips were more efficient than blades of relatively uniform width when operating at power coefficients greater than 0.1 and at advance ratios less than those for maximum efficiency. An explanation of the difference is deduced from wake survey data. Incidental results are evidence of nonindependence of blade elements and of the undesirability of highly cambered blade profiles.

Calculation of Counterrotating Propellers. F. Ginzel. (*ZWB, Forschungsbericht Nr. 1752, January 25, 1943*). *U.S., N.A.C.A., Technical Memorandum No. 1208*, March, 1949. 61 pp., figs. 16 references.

A method, similar to Walchner's for the calculation of the single propeller in the free air stream, is developed for counterrotating propellers and the results are compared with test measurements. Important design dimensions, simple formulas for the gain in ideal efficiency, and a survey of the behavior of the propeller for various operating conditions are given.

Propeller Flutter. M. J. Turner and James B. Duke. *Journal of the Aeronautical Sciences*, Vol. 16, No. 6, June, 1949, pp. 323–336, figs. 16 references.

A procedure for the analysis of classical subsonic torsion-bending flutter of propellers, which extends the earlier work by Loring for nonrotating airfoils. Generalized coordinates and matrix notation are employed in the analysis. Vibration modes of a nonrotating blade are employed as basic displacement shapes. The flutter equations may be formulated for a single blade without loss of generality with respect to the mechanism of flutter. Because of initial twist, the blade elements undergo vibratory displacements in the direction parallel to the relative wind and create additional lift forces and moments. These have been incorporated in the analysis. Theoretical expressions are derived for the required aerodynamic coefficients. An iterative procedure is outlined for the calculation of flexural modes of a nonrotating blade. Because of the presence of centrifugal coupling terms in the equations of equilibrium, changes in mode shape with rotational speed are taken into account.

On Wind Tunnel Tests and Computations Concerning the Problem of Shrouded Propellers. W. Kruger. (*ZWB, Forschungsbericht Nr. 1949, January 21, 1944.*) *U.S., N.A.C.A., Technical Memorandum No. 1202*, February, 1949. 79 pp., illus., diagrs., figs. 11 references.

Effect of the shape of propeller and shroud upon the aerodynamic coefficients of the propulsion unit. The highest efficiency measured in wind-tunnel tests, 0.71, can be improved by shroud profiles of small chord and thickness. The use of a nose split flap doubles the static thrust of thin shroud profiles with small nose radius. Calculations are based on the assumption that the slipstream cross section depends solely on the shape of the shroud and not on the propeller loading. This is confirmed experimentally and by flow photographs for a shroud with small circulation. Calculation and tests for efficiency and static thrust are in good agreement.

Aeromatic's New Altitude Control; Manually Selective Device Affords Infinite Number of r.p.m. Settings. *Aviation Week*, Vol. 50, No. 13, March 28, 1949, p. 28, illus.

A Statistical Note on the Variation of Porosity of Nylon Fabric to Specification D.T.D. 556A. A. Glaskin. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2313*, June, 1945. 12 pp., figs. British Information Services, New York. $0.90.

Research Facilities (50)

Discussion of German Aeronautical Research. Floyd K. Beach, J. J. Green, and others. *The Engineering Journal*, Vol. 32, No. 3, March, 1949, pp. 137–140, fig.

Rotating Wing Aircraft (34)

Limitations in Helicopter Design. J. A. J. Bennett. *Helicopter Association of Great Britain, Journal*, Vol. 1, No. 1, July-August-September, 1947, pp. 24–43, illus., diagrs., figs.

New Utility Helicopter (Doman Pelican) Being Built. *Aviation Week*, Vol. 50, No. 13, March 28, 1949, p. 14, illus.

Propeller Copters Are Funny Birds. *Popular Science Monthly*, Vol. 154, No. 4, 1949, pp. 140, 141, illus. Basic designs proposed for aircraft incorporating both fixed and rotating wings.

Looping Helicopter (Piasecki XHJP-1). *Canadian Aviation*, Vol. 22, No. 4, April, 1949, pp. 23, 42, illus.

Stanley Hiller's New Windmill (Hiller 360). Gaither Littrell. *Flying*, Vol. 44, No. 5, May, 1949, pp. 34, 35, 73, illus.

Some Problems of Helicopter Operation and Their Influence on Design. Reginald Brie. *Helicopter Association of Great Britain, Journal*, Vol. 1, No. 1, July-August-September, 1947, pp. 5–23, illus.

The Use of Wind Machines and Helicopter Flights for Frost Protection. Robert T. Small. *American Meteorological Society,*

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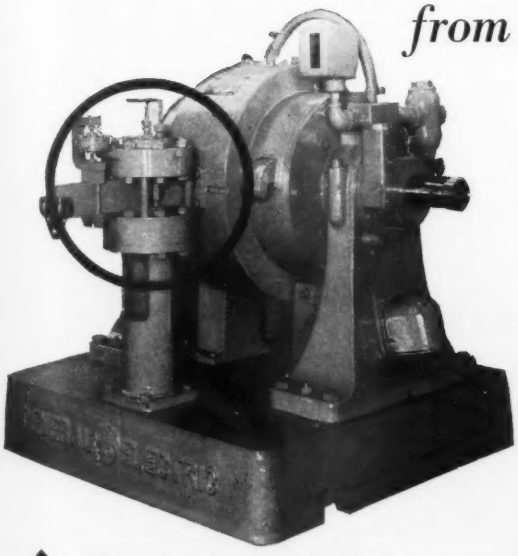

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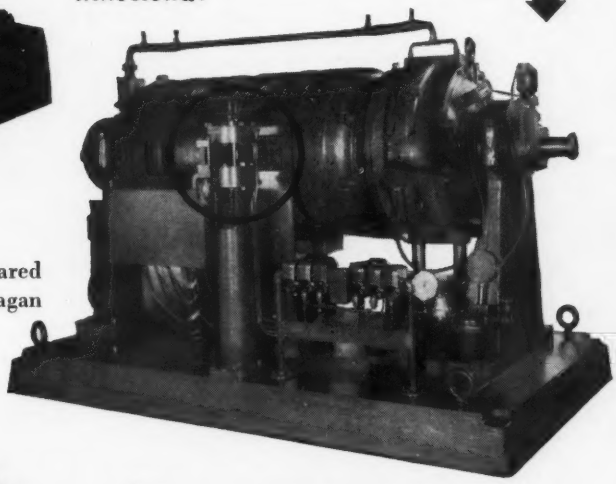

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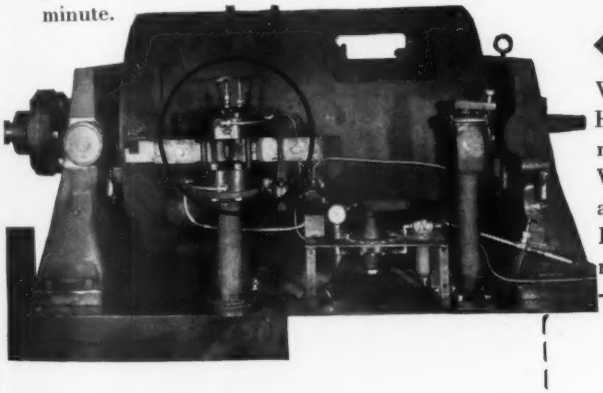

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Bulletin, Vol. 30, No. 3, March, 1949, pp. 79–85, illus., figs. 1 reference.

Investigations of the use of stationary wind machines and low-helicopter flights as a means of mixing the layer of warm air that normally exists during the night at 300 to 800 ft. with the colder surface layer.

Sciences, General (33)

The Morphological Method of Analysis and Construction. F. Zwicky. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 461–470. 2 references. $5.50.

MATHEMATICS

The Statistical Analysis of Experimental Data. B. Saravanos. *Aircraft Engineering*, Vol. 21, No. 241, March, 1949, pp. 64–70, 75, figs.

H. Rissik's use of Probability Graph Paper for determining characteristics of observed frequency distributions which are limited to a normal, and for which only parameters associated with the normal curve of error are required, is extended to the description of nonnormal distributions and to the determination of some of their characteristics. An illustrative analysis is given of unimodal skew frequency distributions, one positive and the other negative. The method is, in principle, independent of lengthy numerical calculations, reduces the tendency to cumulative error, and enables a visual check at all stages.

Some Analytical Aspects of the Problem of Smoothing. I. J. Schoenberg. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 351–370. 9 references. $5.50.

Some Remarks on the Inequality of Tchebychef. Herbert Robbins. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 345–350. $5.50.

Das Eigenwertiproblem von $\Delta u + \lambda u = 0$ in Halbrohren (The Eigen-Value Problem $\Delta u + \lambda u = 0$ in Half Tubes). Franz Rellich. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 329–334. $5.50.

On a Theorem of Frobenius. Hans Rademacher. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 301–305. 1 reference. $5.50.

Arithmetical Methods for the Dating of Babylonian Astronomical Texts. O. Neugebauer. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 265–275. $5.50. The solution of difference sequences of the first and second order which periodically increase and decrease between given limits.

Functions on a Metric Space and a Setting for Isoperimetric Problems. Marston Morse. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 253–263. 2 references. $5.50.

On the Convergence of Solutions of Difference Equations. Hans Lewy. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 211–214. 1 reference. $5.50. A study in explicit terms of the passage to the limit of the solution of the equation for cylindrical waves when the method of Courant, Friedrichs, and Lewy is used to establish convergence.

Remarks on the Perturbation Formulae of Brillouin and Wigner. H. A. Kramers. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 205–210. 4 references. $5.50.

Extremum Problems With Inequalities as Subsidiary Conditions. Fritz John. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 187–204. 9 references. $5.50.

An extension of Lagrange's multiplier rule to the case in which the subsidiary conditions are inequalities instead of equations. Since in this situation the multipliers may always be assumed to be positive, it is possible to obtain sufficient conditons for the occurrence of a minimum in terms of the first derivative only.

Zur Topologie Der Komplexen Mannigfaltigkeiten (On the Topology of Complex Manifolds). H. Hopf. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 167–185. 9 references. $5.50.

Sur Le Cas Anormal Du Probleme De Cauchy Pour L'Equation Des Ondes (On the Irregular Case of the Problem of Cauchy for the Equation of Waves). J. Hadamard. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 161–165. 2 references. $5.50.

Criteria for the Discrete Character of the Spectra of Ordinary Differential Operators. K. O. Friedrichs. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 145–160. 15 references. $5.50.

Angles Between Flat Subspaces of a Real n-Dimensional Euclidean Space. Donald A. Flanders. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 129–138. 4 references. $5.50.

On Discontinuous Groups of Isometric Transformations of the Non-Euclidean Plane. W. Fenchel and J. Nielsen. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 117–128, figs. 1 reference. $5.50.

Kellogg's Uniqueness Theorem and Applications. Griffith C. Evans. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 95–103. 3 references. $5.50.

On the Problem of Dido. Herbert Busemann. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 63–73, figs. 3 references. $5.50.

An extension of the Convexity Principle which shows that it leads to the necessary conditions for the Problem of Dido in a general Minkowski plane and to the Brunn-Minkowski Theorem. One of the corrollaries extended to n dimensions suggests that in isoperimetric problems the study of general integrands can frequently be reduced to the case of quasiregular integrands.

On a Structure Theorem for Closed Modules in an Infinite-Dimensional Space. Harald Bohr and Erling Følner. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 45–62. $5.50.

Bemerkungen zu Den Grundlagen Der Geometrie (Notes on the Bases of Geometry). Paul Bernays. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 29–44, figs. 2 references. $5.50.

The Infinity of Generalized Hyperbolic Planes. Reinhold Baer. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 21–27. 3 references. $5.50.

Über Mittelwertgleichungen, Die Mehreren Partiellen Differentialgleichungen 2. Ordnung Zugeordnet Sind (Concerning Mean-Value Equations for a Number of Partial Differential Equations of the Second Order). Leifur Asgeirsson. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 7–20. 4 references. $5.50.

Linear Mappings and the Existence of a Normal Basis. Emil Artin. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 1–5. $5.50.

The Foundation of Algebraic Geometry; A Very Incomplete Historical Survey. B. L. van der Waerden. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 437–449. $5.50.

Indefinite Quadratische Formen Und Modulfunktionen (Indefinite Quadratic Forms and Modulus Functions). Carl Ludwig Siegel. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 395–406. $5.50.

On the Isoperimetric Inequality for Saddle Surfaces With Singularities. Max Shiffman. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York,

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Symplectic Groups and Null Systems. H. Schwerdtfeger. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 371–382. $5.50.

A Proof of the First Principal Theorem on Conformal Representation. Constantine Caratheodory. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 75–83. $5.50.

On the Precision of a Certain Procedure of Numerical Integration. Harry D. Huskey. *U.S., National Bureau of Standards, Journal of Research,* Vol. 42, No. 1, January, 1949, pp. 57–62, tables. Available also as Research Paper No. RP1950. U.S. Govt. Printing Office, Washington. $0.10.

Systematic rounding-off errors can occur in numerical integration irrespective of the number of digits kept in the contributions to the integral. Criteria are set up to detect cases in which this cumulative error may be serious.

MECHANICS—VIBRATION

Theory of the Damped Dynamic Vibration Absorber for Inertial Disturbances. J. E. Brock. *Journal of Applied Mechanics,* Vol. 16, No. 1, March, 1949, pp. 86–92, figs. 2 references.

Vibration Control of Engines. Lloyd E. Muller. *Product Engineering,* Vol. 20, No. 4, April, 1949, pp. 86–89, illus., diagrs., figs. Control of linear vibration by correct mounting; method for comparing the performance of different mounting materials; and the effect of natural rubber on damping efficiency.

Damped Oscillations of a Spherical Mass of an Elastic Fluid. J. M. Burgers. (*Delft, Technische Hoogeschool, Laboratorium voor Aero- en Hydrodynamica, Mededeeling No. 59.*) *Nederlandsche Akademie van Wetenschappen, Verhandelingen,* Vol. 51, No. 10, 1948. 13 pp., fig. 7 references. (Reprint.) (In English.)

PHYSICS

The Freezing of Supercooled Water. N. Ernest Doresy. *American Philosophical Society, Transactions,* Vol. 38, Part 3, November, 1948. 328 pp., figs. 156 references.

An investigation of the supercooling and freezing of specimens of distilled and natural air-free and air-saturated water. Comparison of results, with those demanded by the kinetic theory and the homogeneous theory of freezing, showed errors in the assumptions incompatible with the restraints inherent in the problem. An explicit heterogenous theory of freezing is outlined, which accounts, qualitatively, for the phenomena observed with each of various types of mechanical disturbance that were introduced during the freezing of supercooled water and with each of several solutes that affected the initiation of freezing when immersed solids were rubbed together.

Structures (7)

Flutter of Systems With Many Freedoms. W. J. Duncan. *The Aeronautical Quarterly (Royal Aeronautical Society, London),* Vol. 1, Part 1, May, 1949, pp. 59–76. 12 references.

Methods for calculating the critical flutter speeds, and the nature of the motion at these speeds, for systems with a large number of degrees of freedom. The increased labor of calculation with increasing number of degrees of freedom gives rise to two problems: (1) the choice of a minimum set of degrees of freedom which will give adequate calculated results; and (2) the choice of the method of calculations. The choice of a minimum set of freedoms is based on the equation of energy and on the use of the Lagrangian dynamical equation corresponding to any proposed additional freedom. The orthodox systematic method of calculation yields all desired information but is unworkably laborious above three degrees of freedom. R. A. Frazer's method saves effort when the number of freedoms is large. Matrices are insufficiently developed to be labor saving and in the method of Duncan, Collar, and Lyon quick success depends on a good preliminary estimate of the critical speed and frequency.

Station Functions and Air Density Variations in Flutter Analysis. Manfred Rauscher. *Journal of the Aeronautical Sciences,* Vol. 16, No. 6, June, 1949, pp. 345–353, figs. 2 references.

Station Functions have been devised as a means of correlating the motions of the masses at different stations in a vibrating system. The tie-in is analogous to that between the ordinate of a curve at a series of stations in the development of Simpson's Rule. The use of the Functions combines the conveniences of working with discrete masses and of having continuously defined deflections. The Functions are shown to serve well both for the calculation of vacuum modes and for the determination of flutter modes. Air density variations have been considered as a means of fixing the flutter conditions corresponding to a chosen value of the flutter parameter k. The attractiveness of the scheme lies in its automatic coverage of the flutter performance at various altitudes and in its avoidance of calculations for hypothetical k's at air densities fixed in advance. The method becomes especially valuable when allowance is made for aerodynamic span effects, which greatly increase the labor of trial variations of k.

A Method of Least Square Adjustment for Measured Wing Deflections. Dale R. Branchflower. *Journal of the Aeronautical Sciences,* Vol. 16, No. 6, June, 1949, pp. 375, 376, 383. 2 references.

The dynamic characteristics of an airplane wing are predicted from the theoretical bending-torsion modes of the wing. The validity of these predictions depends upon experimental verification of the theoretical modes. For this purpose, measured wing deflections are obtained from ground vibration tests. The principles of least square adjustment are applied to the measured modes in such a manner that a best fit is obtained for the kinetic energy. The measured deflections are expressed as a series of theoretical deflections. Probably the most important feature of the method is that the coefficients in the series are a numerical measure of the similarity of theoretical and experimental modes.

Flutter of a Uniform Wing With an Arbitrarily Placed Mass According to a Differential-Equation Analysis and a Comparison With Experiment. Harry L. Runyan and Charles E. Watkins. *U.S., N.A.C.A., Technical Note No. 1848,* March, 1949. 50 pp., figs. 12 references.

The calculation of the flutter speed of a uniform wing carrying an arbitrarily placed concentrated mass. The method, an extension of a recently published work by Goland and Luke, involves the solution of the differential equations of motion of the wing at flutter speed and therefore does not require the assumption of specific normal modes of vibration. The differential equations are solved by operational methods. A brief discussion of this method is given. Calculations for a specific problem agree well with experimental results.

The Elastic Twist of Straight Wings for Symmetrical Load Conditions. Walther Boccius. *U.S., Air Force, Technical Report No. F-TR-1190-ND (GS-USAF Wright-Patterson Air Force Base No. 109),* December, 1948. 60 pp., diagrs., figs. 6 references.

An empirical method of approximation for determining elastic wing twist. General formulas, based on an assumed shape of the twist curve and fixed wing-tip deflection, are derived which, neglecting small members, provide uncoupled, separated relations for twisting and bending. From these the twist can be found by one or two steps of iteration. Because the twist progressively increased with positive lift increments, there are two stability criteria distinguished by two divergence speeds for constant fuselage position and constant wing lift. Extensive calculation of wings with constant and variable torsional rigidity along the span show that positive twists vary with trigonometrical functions, whereas negative twist obey hyperbolic functions. Since the stability criteria depend on the loading conditions, a safety factor should be allowed to prevent the approach of the divergence speed in dives. Formulas and graphs show the influence of twist on gust effect for wings of constant and variable torsional rigidity along the wing span. Most recent German preliminary design criteria incorporated a safety factor to accommodate the effect of unforeseen twists on maximum loading.

A Boundary Value Problem for a Hyperbolic Differential Equation Arising in the Theory of the Non-Uniform Supersonic Motion of an Aerofoil. Olga Taussky. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 421–435, figs. 5 references. $5.50. Possio's integral is derived by a generalization of the procedure adopted by Temple and Jahn. The method of the proof automatically establishes the uniqueness of the solution.

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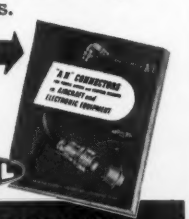

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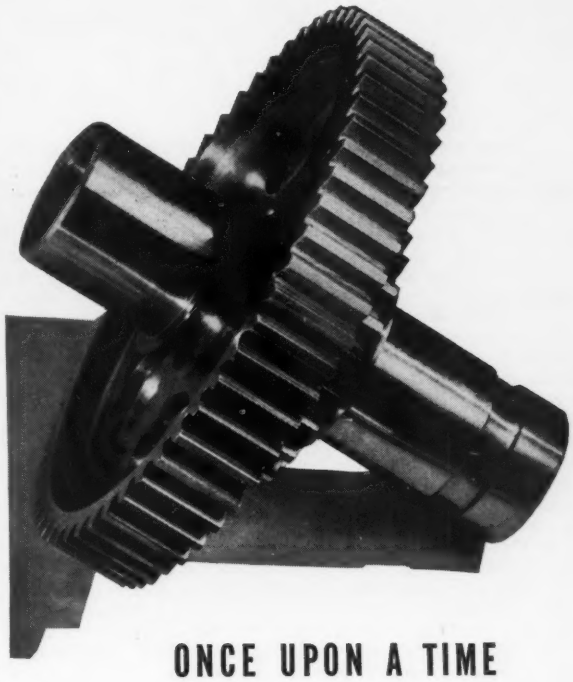

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An Example of Efficient Design Through Strain Measurements. John C. New. *Society for Experimental Analysis, Proceedings*, Vol. 6, No. 2, 1948, pp. 111–119, illus., diagrs., figs.

Readers' Forum: Oscillating Airfoils at Mach Number 1. N. Rott. *Journal of the Aeronautical Sciences*, Vol. 16, No. 6, June, 1949, p. 380.

Readers' Forum: On the Oscillating Rectangular Airfoil at Supersonic Speeds. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 16, No. 6, June, 1949, p. 381. 3 references.

Compression Tests of Curved Panels With Circular Hole Reinforced With Circular Doubler Plates. Wilhelmina D. Kroll and A. E. McPherson. *Journal of the Aeronautical Sciences*, Vol. 16, No. 6, June, 1949, pp. 354–364, illus., figs. 8 references.

A set of 14 panel specimens was tested in compression to determine the effect of sheet curvature on the strain distribution around a circular hole in the sheet. Specimens with no reinforcement around the hole and specimens with doubler plate reinforcement of the hole were included. The radius of curvature of the sheet ranged from 10 in. to infinity. Identical specimens were tested with and without reinforcement in order to evaluate the effectiveness of the reinforcement. For the unreinforced specimens, it was found that the plane stress theory for flat sheet predicted the mid-thickness strain distribution within the errors of observations. For the specimens with reinforcements, the plane stress theory gave strains that, in the vicinity of the hole, were lower than those observed at the extreme fiber of the sheet and higher than those observed at the extreme fiber of the reinforcement. This was attributed to the fact that the reinforcement was not integral with the sheet and did not carry its share of the load. This is borne out further by the observation that the shortening of the hole diameter was essentially the same for panels with and without reinforcements.

The Distortion of a Flat Rectangular Plate in its Own Plane. H. L. Cox. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2200*, July, 1945. 37 pp., figs. 13 references. British Information Services, New York. $2.05.

Application of the principle of least total energy to determination of displacements in an elastic medium. Apart from uniform dilation, the distortion of the plate may be analyzed into four components: shear parallel to the plate edges; shear at 45° to the plate edges; and bending with neutral axes parallel to each of the two pairs of edges. The rectangular plate may also be sheared into a rhombus by a system of purely normal loads applied to its edges, and the displacements of the plate edges along their own lengths under this system of load is not far from uniform.

Plastic Buckling of Simply Supported Compressed Plates. Richard A. Pride and George J. Heimerl. *U.S., N.A.C.A., Technical Note No. 1817*, April, 1949. 22 pp., illus., figs. 11 references.

Tests were made of 14S-T6 aluminum-alloy square tubes to determine the critical compressive stress of simply supported flat plates in the plastic range. Excellent agreement is shown with Stowell's theory for plastic buckling, which is based upon a deformation theory of plasticity; there is close agreement with two other deformation-type theories of plastic buckling and with the secant-modulus method and marked disagreement with a buckling theory based upon a flow theory of plasticity.

Buckling of Stiffened, Flat, Plywood Plates in Compression; A Single Stiffener Parallel to Stress Face Grain of Plywood at 45° to its Edges. C. B. Norris and L. A. Ringelstetter. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1553-C*, October, 1948. 13 pp., illus., figs.

Data on the Compressive Strength of 75S-T6 Aluminum-Alloy Flat Panels With Longitudinal Extruded Z-Section Stiffeners. William A. Hickman and Norris F. Dow. *U.S., N.A.C.A., Technical Note No. 1829*, March, 1949. 21 pp., illus., figs., tables. 13 references.

Panels in which the ratio of the thickness of the stiffener material to the skin material varies from 0.4 to 1.0 and the ratio of stiffener spacing to skin thickness varies from 15 to 40.

Three-Dimensional Solution for the Stress Concentration Around a Circular Hole in a Plate of Arbitrary Thickness. E. Sternberg and M. A. Sadowsky. *Journal of Applied Mechanics*, Vol. 16, No. 1, March, 1949, pp. 27–38, figs. 8 references.

On the Stability of Plates Reinforced by Ribs. J. M. Klitchieffe. *Journal of Applied Mechanics*, Vol. 16, No. 1, March, 1949, pp. 74–76, figs. 2 references.

Sandwich Panels and Cylinders Under Compressive End Loads. D. M. A. Leggett and H. G. Hopkins. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2262*, August, 1942, 22 pp., figs. 3 references. British Information Services, New York. $1.30.

Reinforced Circular Cutouts in Plane Sheets. H. Reissner and M. Morduchow. *U.S., N.A.C.A., Technical Note No. 1852*, April, 1949. 60 pp., illus., figs. 1 reference.

Some New Problems on Shells and Thin Structures. V. S. Vlasov. (*U.S.S.R., Izvestia Akademii Navk, No. 1, 1947*, pp. *27–53.*) *U.S., N.A.C.A., Technical Memorandum No. 1204*, March, 1949. 46 pp., figs. 10 references.

Theory of cylindrical shells and its application to stress analysis, vibration analysis, and buckling analysis of shells. Only the membrane forces in the shell and a circumferential bending moment and its associated shear force are considered. The theory is developed both with and without the geometrical restriction of zero shear strain and zero circumferential strain.

Open Convex Surfaces Which Are Rigid. J. J. Stoker. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 407–420. 13 references. $5.50.

Notes on the Foundations of the Theory of Small Displacements of Orthotropic Shells. F. B. Hildebrand, E. Reissner, and G. B. Thomas. *U.S., N.A.C.A., Technical Note No. 1833*, March, 1949. 59 pp. 14 references.

A survey of various systems of equations which have been given in the literature for the analysis of small deflections of thin elastic shells. Previously known results for isotropic shells are reformulated for shells which are orthotropic to the extent that the normal to the middle surface of the shell may be a preferred elastic axis. A new system of equations for the analysis of shells includes the effects of transverse shear and normal stresses. The assumed orthotropy of the shell facilitates the identification of the separate effects of transverse stresses, which ordinarily are neglected.

Stress-Analysis Beyond the Elastic Range. Alfred M. Freudenthal. *Society for Experimental Stress Analysis, Proceedings*, Vol. 6, No. 2, 1948, pp. 131–140, diagrs., figs. 4 references.

The Basic Elastic Theory of Vessel Heads Under Internal Pressure. G. W. Watts and W. R. Burrows. *Journal of Applied Mechanics*, Vol. 16, No. 1, March, 1949, pp. 55–73, diagrs. 47 references.

The Elastic Stability of Flat Sandwich Plates. A. Van Wijngaarden. *Amsterdam, Nationaal Luchtvaartlaboratorium, Reports and Transactions*, Vol. 13, 1947, Report No. S.319. 20 pp., figs. 3 references. (Revised.)

Effects of Shear Deformation in the Core of a Flat Rectangular Sandwich Panel; Stiffness of Flat Panels of Sandwich Construction Subjected to Uniformly Distributed Loads Normal to Their Surfaces—Simply Supported Edges. W. J. Kommers and C. B. Norris. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1583-A*, October, 1948. 23 pp., illus., diagr., figs. 5 references.

On Generalized Potential Theory and on the Torsion of Shafts. Alexander Weinstein. *Studies and Essays, Presented to R. Courant on His 60th Birthday, January 8, 1948.* New York, Interscience Publishers, Inc., 1948, pp. 451–460, figs. 5 references. $5.50.

Effects of Impact on Simple Elastic Structures. J. M. Frankland. *Society for Experimental Stress Analysis, Proceedings*, Vol. 6, No. 2, 1948, pp. 7–27, illus., figs. 7 references.

An analysis of the reaction of typical structures to impact loading. Although the model system is a simplification, it describes simple structures with sufficient accuracy for it to be used as a basis for structural design and for the development of instruments to measure impact effects. The effects of nonoscillating disturbances are governed mainly by the abruptness of the original application of force and by the duration of the disturbance in terms of the natural period of the system. For oscillating disturbances there is an additional influence similar to resonance in the steady-state condition.

A Method of Estimating Equivalent Static Loads in Simple Elastic Structures. G. E. Hudson. *Society for Experimental Stress Analysis, Proceedings*, Vol. 6, No. 2, 1948, pp. 28–40, figs. 3 references.

A graphic method of estimating the static load that will produce in a simple structure a deflection equal to its peak deflection under dynamic load. It permits an estimation to be made of this

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peak and of the time to reach the peak. A simple extension of these constructions affords a means of finding graphically the motion of a linear elastic system under dynamic loading.

Matrix Methods for Calculating Cantilever-Beam Deflections. Stanley U. Benscoter and Myron L. Gossard. *U.S., N.A.C.A., Technical Note No. 1827*, March, 1949. 58 pp., figs. 7 references.

Numerical integration in the calculation of cantilever-beam deflections due to distributed loading is presented in matrix form to give it the advantages of an influence-coefficient method. The results, when compared with exact solutions, show that weighted matrices maintain accuracy and require less calculation.

Bending of Beams With Creep. E. P. Popov. *Journal of Applied Physics*, Vol. 20, No. 3, March, 1949, pp. 251–256, figs. 12 references. A method of calculating stresses and deflections at any desired time level by using Bernoulli's hypothesis of plane sections and techniques for interpretation of the relaxation creep test .

On the Extended Use of Kleinlogel's Rahmenformeln. I. F. Morrison. *Canadian Journal of Research, Section F, Technology*, Vol. 26, No. 12, December, 1948, pp. 552–564, figs.

In moment-area method for the analysis of multiple frames the complex structure is dissociated into structure units that can be found in Kleinlogel's Rahmenformeln, a book of diagrams and formulas for simple frames of various shapes, support conditions, and loadings. The technique reduces the number of simultaneous linear equations in the analysis.

The Equivalent Static Accelerations of Shock Motions. J. P. Walsh and R. E. Blake. *Society for Experimental Stress Analysis, Proceedings*, Vol. 6, No. 2, 1948, pp. 150–158, illus., figs. 4 references.

Experimental Determination of Aircraft Loads. Bernard D. Haber. *Society for Experimental Stress Analysis, Proceedings*, Vol. 6, No. 2, 1948, pp. 120–130, figs. 1 reference.

Interim Report on Measurements of Landing Loads on a Ski Plane. J. P. Uffen and A. D. Wood. *Canada, National Research Council, Division of Mechanical Engineering, Aerodynamics Laboratory, Report No. MM-210*, October, 1948. 34 pp., illus., diagrs., figs. 4 references.

A Large Displacement Deformeter Apparatus for Stress Analysis With Elastic Models. William J. Eney. *Society for Experimental Stress Analysis, Proceedings*, Vol. 6, No. 2, 1948, pp. 84–93, illus., diagrs., figs.

Law of Failure of Stresscoat. A. J. Durelli and T. N. DeWolf. *Society for Experimental Stress Analysis, Proceedings*, Vol. 6, No. 2, 1948, pp. 68–83, figs. 6 references.

Thermodynamics (18)

Investigation of the Variation of Point Unit Heat-Transfer Coefficients for Laminar Flow Over an Inclined Flat Plate. R. M. Drake. *Journal of Applied Mechanics*, Vol. 16, No. 1, March, 1949, pp. 1–8, illus., figs. 8 references.

Many applications of heat-transfer phenomena by forced convection require a knowledge of heat transfer from simple geometric bodies. Investigations of the flat plate have been limited, in general, to studies of isothermal plates of 0° angle of incidence in laminar flow. There is little data on turbulent flow, nonisothermal plates, or inclined plates. Forced-convection heat-transfer data for an inclined nonisothermal plate with a constant specific rate of heat flow can be correlated and represented by an equation that for laminar flow is similar in slope to the theoretical equation but is larger by 30 per cent in absolute value. This variance can only be partly explained by an analysis of the behavior of a nonisothermal plate.

Precision of Heat Transfer Measurements With Thermocouples; Insulation Error. W. A. Mohun. *Canadian Journal of Research, Section F, Technology*, Vol. 26, No. 12, December, 1948, pp. 565–583, diagrs., figs. 1 reference. Calculation of the temperature variation in insulated thermocouple lead wires when the path of the wire is not isothermal.

Water-Borne Aircraft (21)

Effect of Forebody Warp on the Hydrodynamic Qualities of a Hypothetical Flying Boat Having a Hull Length-Beam Ratio of 15. Arthur W. Carter and Irving Weinstein. *U.S., N.A.C.A., Technical Note No. 1828*, March, 1949. 47 pp., illus., diagrs., figs. 7 references.

Warping the planing bottom and increasing its angle of dead rise progressively from step to bow, appreciably increased the range of stable trim between the lower and upper trim limits of stability, although the c.g. limits of stability were reduced. Landing stability was improved by warping the forebody. Bow-spray characteristics were substantially better for the hull with the warped forebody than for the hull with the basic forebody. The high-speed water resistance was slightly greater for the hull with the warped forebody and the overall take-off performance was slightly inferior to that of the hull with the basic forebody. Warping the forebody had a negligible effect on the take-off behavior in waves. The maximum vertical and the maximum angular accelerations were reduced during landings in waves, but the maximum oscillations in trim and rise were the same as those for the hull with the basic forebody.

Tank Tests to Determine the Effect on Planing-Tail Hulls of Varying Length, Width, and Plan-Form Taper of Afterbody. John R. Dawson, Robert C. Walter, and Elizabeth S. Hay. *U.S., N.A.C.A., Report No. 844*, 1946. 8 pp., diagrs., figs. 4 references. U.S. Govt. Printing Office, Washington. $0.15.

A typical conventional hull had 40 per cent greater resistance at the hump speed and from 75 to 100 per cent greater resistance near the getaway speed than planing-tail hulls. Decreasing the width of the afterbody of a planing-tail increased the resistance at hump speed, decreased the trimming moments required to obtain best trim, and moved forward the location of the c.g. required to give best trim at the hump speed. Increasing the length of the afterbody of a planing-tail decreased the resistance over almost the whole speed range, reduced the variation of trim with speed, and moved aft the location of the c.g. required for best trim at the hump speed. Tapering the plan form of the afterbody reduced the resistance over the lower half of the speed range and had little effect on the resistance at high speeds. Plan-form taper also moved forward the location of the c.g. required to obtain best trim at the hump speed.

Amphibiana; Some Reminiscences of Wheels-and-Water Aircraft, and a Plea for Their Development. Allan F. Voak. *Flight*, Vol. 55, No. 2021, March 31, 1949, pp. 378–380, illus.

Wind Tunnels (17)

Jet-Boundary and Plan-Form Corrections for Partial-Span Models With Reflection Plane, End Plate, or No End Plate in a Closed Circular Wind Tunnel. James C. Sivells and Owen J. Deters. *U.S., N.A.C.A., Report No. 843*, 1946. 30 pp., figs. 9 references. U.S. Govt. Printing Office, Washington. $0.20.

Complete jet-boundary and plan-form corrections to be applied to test data for a partial-span model. The method is used to calculate values of lift, drag, pitching-moment, rolling-moment, and yawing-moment coefficients. For the reflection-plane condition, with the exception of corrections to the rolling-moment coefficient, the jet-boundary corrections are smaller than for either of the other end conditions, as were the plan-form corrections for all corrections that depended upon the wing lift distribution. A reflection plane should be used wherever possible for tests of partial-span models.

Linear Theory of Boundary Effects in Open Wind Tunnels With Finite Jet Length. S. Katzoff, Clifford S. Gardner, Leo Diesendruck, and Bertram J. Eisenstadt. *U.S., N.A.C.A., Technical Note No. 1826*, March, 1949, 97 pp., illus., figs. 17 references.

Wind-tunnel boundary interference in an open wind tunnel with closed entrance and exit sections. Electrical analogies, in which electrical potential corresponds to velocity potential, and in which electrical potential corresponds to acceleration potential, might be used for solving the flow. Solutions are derived for four types of two-dimensional open tunnels including one in which the pressures on the two free surfaces are not equal. Numerical results are given for each case. In general, if the lifting element is more than half the tunnel height from the inlet, the boundary effect at the lifting element is the same as for an infinitely long open tunnel. A general method for calculating the boundary effect in an open tunnel of finite jet length is given with numerical results for a lifting element concentrated at a point on the axis.

N. A. (North American Aviation, Inc.) Supersonic Wind Tunnel for Testing Up to 4000 MPH. O. W. Boden. *Automotive Industries*, Vol. 100, No. 7, April 1, 1949, pp. 36–38, illus., diagrs.

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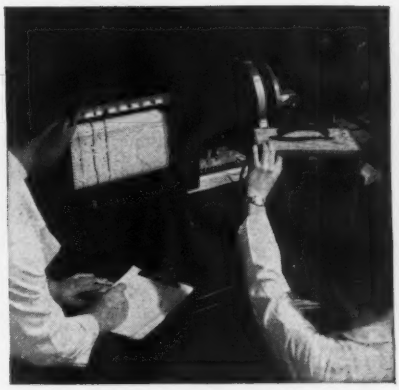

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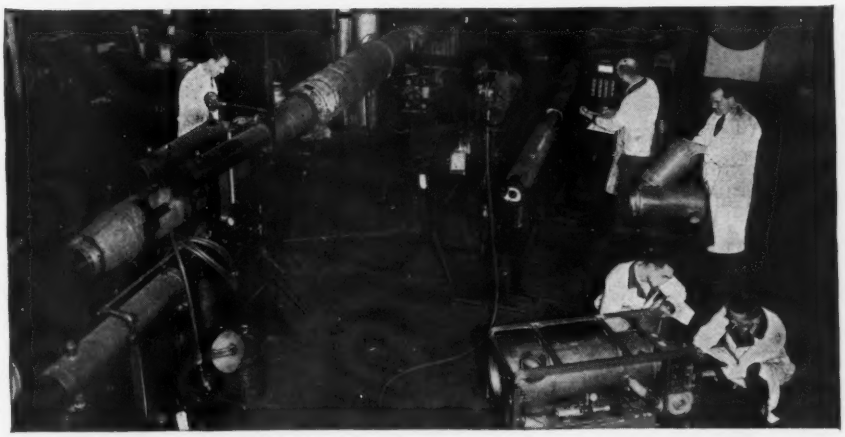

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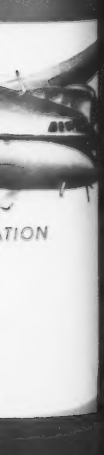

Aeronautical Reviews

Books

Computation Curves for Compressible Fluid Problems

By C. L. Dailey and F. C. Wood. New York, John Wiley and Sons, Inc., 1949. 33 pp., charts. $2.00.

In the words of the authors: "With the recent development of transonic airplanes and supersonic missiles, the theory of compressible flow, already developed by physicists and mathematicians, became important to the engineer." Such problems as wind-tunnel nozzle design, diffuser design, and jet engine design having become commonplace details, the kinetic and dynamic characteristics of compressible fluids have assumed the highest importance.

With this realization, the authors have attempted to present a unified, comprehensive, graphical summary of the flow characteristics of a compressible fluid pertaining to reversible adiabatic flows, flows through shock waves, and conical flows.

An effort has been made to explain each relation depicted so that its meaning and limitations can be understood without recourse to any other source. In this the authors have succeeded well; the subject matter has been handled in such a clear manner as to be completely self-sufficient. Those with little familiarity with the subject will be pleased at the straightforward and fairly rigorous treatment.

The characteristics tabulated were chosen on the basis of several years' experience of the authors with the problems arising in the practical applications of compressible flow theory. They are presented graphically in three sections and are preceded by 33 pages of theory.

In the first section, the local variables of state, expressed in terms of the respective stagnation values, are shown as functions of the local Mach Number. Because of the analogy between the different variables, it is convenient to have a set of curves relating them to the local Mach Number so that the entire set of quantities can be determined when any one of them is known. These relations are depicted in the three charts of the first section entitled "Energy Relations."

The problem of heat addition in a constant area channel can also be handled by application of the conservation laws. The added heat appears, then, as an increase in the stagnation temperature in that part of the channel which is downstream of the point of heat addition. Thus, the Mach Number in the after section can be obtained as a function of the Mach Number of the front section and of the amount of heat added.

The second section gives the well-known relations for flow across a plane oblique shock. In other words, it is an amplified version of the oblique shock chart, published in Liepmann and Puckett's text; however, in the charts of Dailey and Wood, a greater and more consistent accuracy is used. In this part also, the Prandtl-Meyer relation for expansion flows is evaluated in graphical form.

The third section gives the results of the Taylor-Maccoll theory for flow past a cone at zero angle of attack and gives a picture of the pressure, Mach Number, and streamline direction for the entire conical flow field. The scales of all curves have been chosen to obtain a consistent accuracy on the order of 1 per cent.

The charts presented were obtained by combining the integrated Taylor-Maccoll equation and the results of the shock-polar theory. This permits one to find the free-stream Mach Number for a given combination of cone angle and surface velocity distribution. However, in an actual physical problem, the situation is reversed. The free-stream Mach Number is known along with the cone angle, and the surface velocity and pressure are to be determined. If the charts are used in this manner, the local Mach Number, the inclination of conical shock front, and the pressure distribution throughout the conical field can be found. The different charts were obtained from extensive calculations, recently published by the Electrical Engineering Department of M.I.T., under the direction of Z. Kopal, which were brought into graphical form. With the critical need for highly accurate information in the design of missiles, the value of these results is apparent. The presence of this group of charts alone makes the text a valuable contribution to the field.

The three sections together, totaling 27 charts, cover a part of almost every conceivable practical problem in compressible flow. There can be no doubt that many aerodynamicists engaged in the field will find this an excellent aid in completing the solutions of daily problems.

DR. H. F. LUDLOFF
Associate Professor of Aeronautical Engineering, New York University

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Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

Vectorial Mechanics

By E. A. Milne. New York, Interscience Publishers, Inc., 1948. 383 pp., diagrs. $7.50.

Professor E. A. Milne's *Vectorial Mechanics* is an excellent textbook on vectors and applied vector analysis to rational mechanics. The subjects treated by vectorial methods are those of elementary classical mechanics up to dynamics of rigid bodies, gyrostatic problems, and impulsive forces. A short chapter on dynamics of systems is given, but the discussion of the general equations of motion has been deliberately excluded by the author to maintain the elementary character of the book. The first four chapters present and develop the necessary motions of vector and tensor analysis used throughout the book.

The author emphasizes the use of vector product relations to the solution of examples and problems and uses it extensively for demonstration and proof of theorems on vector and elementary tensor analysis. One complete chapter is devoted to vector and multiple-vector products. Their counterpart for dyadics and cross products, with the use of idem and alternate tensor, constitute the elementary tensor analysis part of the book.

Chapter VI, entitled "System of Line Vectors," familiarizes the reader with reduction of the system of vectors, equivalence, and vector treatment of geometric problems and prepares the way for the study of statics of rigid bodies. The object (to quote the author) of a mathematical technique, apart from its aesthetic beauty, is to save labor, to avoid the risk of error, and to minimize mental strain. Numerous examples given in this chapter well illustrate the author's point.

Part III of the book is devoted to dynamics, and, as previously stated,

the subjects treated will be familiar to most readers. It therefore constitutes an excellent vehicle of familiarization with vector notations, processes, and manipulations.

The book is well written, the text is clear and easily understandable, and the printing is good. Vectors are distinguished from scalars through the use of Clarendon type. The notations are consistent throughout the book. It is, however, somewhat unfortunate that nomenclature and symbolism in higher and modern algebra is not better coordinated and standardized. Although the subject may seem trivial to professional mathematicians and physicists, it adds somewhat to the difficulty of interpretation through cross references. In the present book the vector product sign of Burali-Forti is used instead of the more common cross of Gibbs.

Numerous examples given throughout the book can be used as exercises and problems and permit the reader to familiarize himself rapidly with the modulus operandi of vector analysis.

A great deal would have been gained, from a busy-reader point of view, by the addition of an alphabetical subject index and notes of cross references.

However, it may be preferable to force the student to gain and retain sufficient knowledge of the subject which would render indexes absolutely useless.

The book of Professor Milne will be most welcomed by readers interested in applied mathematics and wishing to acquire a good working knowledge of vectors and elementary tensor manipulations, and, in particular, by engineers and technical people who feel the necessity of making or renewing acquaintance with the powerful tool of vector analysis. This book can be used as an introduction to the more involved subjects of analytical mechanics and analysis of complex phenomena, such as aeroelastic problems encountered in airplane design.

The methods and processes of modern algebra, now universally used in mathematical physics, are coming in greater favor for more elementary subjects and are appearing with increased frequency in technical literature. More than a passing acquaintance with the subject is now required, since the necessity of understanding the work of others is forever present. In addition, familiarity with notation, and operations on tensors or dyadics matrices, and vectors is not only labor-saving but helps to form a clearer conception of physical problems.

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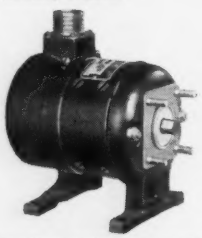

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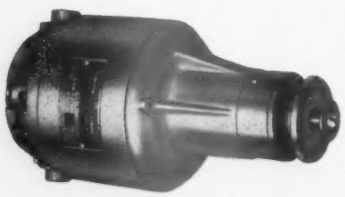

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Airports and Air Traffic

By John Walter Wood. New York, Coward-McCann, Inc., 1949. 159 pp., charts. $3.75.

Airports and Air Traffic, by John W. Wood, imparts sound airport planning thinking. It is concisely and clearly written, and its language leaves no mistake as to what the author is thinking.

The author rightfully states that "We cannot, with safety, plan even the smallest airport unless we take the broadest view of the air traffic involved over a wide surrounding area"; also, any airport must be conceived together with good surface communications in order to assure its usefulness and provide maximum service for the greatest number of people.

Emphasis is placed on the importance of proper site selection, because once this has been done and the construction started, the entire future of the development of any landing facilities and their cost will be directly related to the characteristics of the site selected.

The author emphasizes as a basic requirement the consideration of existing and potential highway arteries according to the type of operation contemplated. This is a most important utility factor in the master-planning of individual airports. His analysis of the classes of airports and breakdown by function is exceedingly thorough and well presented. Important statistics have been included

for the guidance of the airport planner, and there is a pardonable repetition of C.A.A. information in order to provide a ready reference.

I commend this book to anyone entrusted with the planning and management of an airport. *Airports and Air Traffic* should serve to broaden his knowledge and help in formulating decisions on the planning of public facilities applied to a dynamic industry and yet will have to last for a long time to come without becoming totally obsolete.

CHARLES FROESCH
Chief Engineer,
Eastern Air Lines, Inc.

1948 National Survey of Professional Scientific and Engineering Salaries

Los Alamos, N. Mex., Personnel Department, Los Alamos Scientific Laboratory of the University of California, 1949. 24 pp.

"Thar's gold in them thar hills'" can be readily applied to the salary vs. "years-since-Bachelor-degree" curves presented in this 24-page booklet. These curves are the summaries of an interesting survey of salaries paid to scientific and engineering personnel. The presentation is unique, since it does not attempt to draw any conclusion, listing only the conditions of the survey, limitations, and findings. The reader, therefore, is free to dig out whatever "gold" he wishes from the salary curves in the form of his own conclusions and then apply them to his own organization.

The Los Alamos Scientific Laboratory conducts an annual survey to serve as a guide in determining salaries of its present and prospective employees so that they may be maintained at a level that compares favorably with the market elsewhere. A total of 292 organizations contributed salary data to the survey, reporting on 33,202 individual employees, of which 18,968 were engaged in research and 14,234 in engineering activities. This sampling is a little more than 4 per cent of the total number of scientists, engineers, and technicians in this country, as revealed by the 1947 Steelman report of the President's Scientific Research Board. However, this survey does uncover certain basic facts that would, it is felt, be only further solidified as the result of a greater sampling.

Results of this survey indicate that the people possessing a Doctor's degree averaged about $1,200 a year more in salary than those possessing only a Bachelor's degree for the same period of "years-since-degree." This is a significant fact because it illustrates that, for the 3 additional years spent in obtaining the Doctor's degree, it takes the man with only a B.S. degree approximately 8 years in experience to overcome this differential in salary. As an example, the Ph.D.'s salary, 7 years after receiving his B.S. degree (4 years after Ph.D. degree), is averaging approximately $6,000 yearly. It takes the B.S. 15 years after his degree is granted to reach this same salary level. These figures are based upon a "weighted least square line." The actual "weighted average line" of the results indicates an even greater variation within this region. However, this is not too significant, since plus or minus one or two years does not alter the fact that it takes the B.S. degree man two or three times the number of years to catch up to the Ph.D.'s average salary. However, it must not be overlooked that these are averages and that the caliber of men is somewhat higher in the Ph.D department than that for the B.S. men; all of the Ph.D.'s have their B.S. degree, but not all B.S. personnel could make the grade of obtaining a Ph.D. degree. In many individual cases, men with only B.S. degrees are making salaries considerably higher than those of their Ph.D. colleagues. It is also pointed out that there was no appreciable differential indicated for those possessing a Master's degree over that of the Bachelor's.

It is also interesting to note that in the aeronautical field salaries steadily increased with time until the 8 years-since-degree period, and then they started to level out and remain slightly below $6,000 per year for as far as 20 years. This does not hold true for most of the other eight industrial fields shown. Here again a

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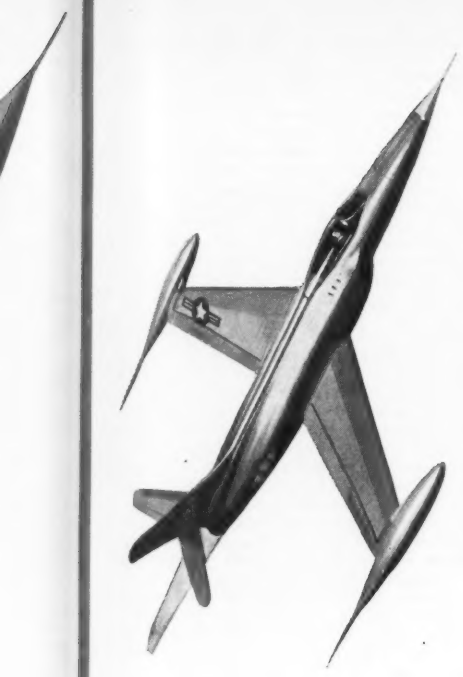

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word of caution—the survey does not take into account administrative and highly supervisory personnel. It is felt that it was a mistake to omit these classes, because the results obtained do not reflect the true possibilities of the increase of salary potential with time in a given field. Furthermore, the survey does not indicate at what level this supervisory separation takes place in the various fields. Many engineers in the aeronautical field, approximately 8 years out of school, have been put into highly responsible and supervisory positions. Therefore, some misinterpretation of the results of this survey are possible. Some significance may be attached to the fact that only seven aircraft companies contributed to this survey. However, most engineers are well aware that the field is so closely interconnected that usually what is true for one company can be applied without too much variation to another and therefore the indication will be reliable.

Comparison of salaries by size of staff is also presented. The conclusion that one may reach is that the larger the staff, the higher the pay. This is particularly true where the staff consists of over 500. That is the only time that the salary-vs.-time curve ever crosses the $7,000 a year mark.

This is the first time that the results of the "Los Alamos" survey have been published. It is hoped that this may be followed by many others because there is a need for reliable salary data in the scientific fields. It is also hoped that many more companies will contribute to it in the future and that some data will be given to show the salary potential in each field, taking into account administrative and highly supervisory personnel.

MAX SOKOL
Project Engineer,
Standard Aeronautical
Indexing System

Book Notes

FUELS & LUBRICANTS

Fuels and Lubricating Oils for Internal Combustion Engines. B. Pugh and J. M. A. Court. New York, Pitman Publishing Corporation, 1949. 169 pp., diagrs. $3.50.

Introductory chapters on hydrocarbon chemistry and on the manufacture of fuels and lubricants from petroleum are followed by discussions of combustion, the antiknock rating of fuels, and the chemical and physical properties of fuels and their significance. Chapters on the general elementary principles of engine lubrication, the meaning and significance of lubricating oil tests, and details of the Cooperative Fuel Research Motor test conclude the book. Both American and British test methods are included in the discussion.

Bibliography on Sprays. Kalman J. DeJuhasz. New York, The Texas Company, Refining Department, Technical and Research Division, 1948. 98 pp.

This is an expansion of a bibliography of fuel sprays and nozzles published in 1932. It contains over 300 annotated references dealing with oil sprays and jets, industrial sprays, and such borderline subjects as dust and powders. The compilation was made under the auspices of the Naval Bureau of Aeronautics and The Texas Company. The arrangement is alphabetical by authors, with a subject index referring to authors' names. The compiler is Professor of Engineering Research at The Pennsylvania State College.

LIBRARY SCIENCE

Aviation Subject Headings, A Concise List for Civil Aviation Libraries or Collections. Compiled by Agnes A. Gautreaux and Mary Lally. New York, Special Libraries Assn., 1949. 56 pp. $1.75.

This is in substance an adaptation of *Subject Headings for the Aeronautical Index*, compiled by N. H. Randers-Pehrson and Arthur G. Renstrom and published in mimeographed form by the Library of Congress in 1940. Approximately 550 principal headings are included, as well as 300 subdivisions of such headings as Air Mail, Airlines, Airports, and Navigation. Indications for cross referencing are liberally supplied, with 800 references to related headings being included. Recommended subdivisions geographically, by dates, or by company names are indicated by simple letter symbols. This is a useful compilation for the alphabetical indexing of material on civil aviation subjects, particularly in operating, management, and economic and legal phases. The compilers are librarians, respectively, with the Civil Aeronautics Administration and American Airlines System.

MATERIALS

Treatise on Powder Metallurgy. Volume I.—Technology of Metal Powders and Their Products. Clause G. Goetzel. New York, Interscience Publishers, Inc., 1949. 778 pp., illus., diagrs. $15.

The author's purpose is to survey, digest, and present the present-day knowledge of powder metallurgy, systematically, in the form of an exhaustive treatment. A brief review of the powder metallurgy process, including industrial applications, and a chapter on its history open this first volume. Methods of production, characteristics, and properties of powders, methods of testing powders, and a survey of over 50 types of commercial powders are next discussed. The conditioning of powders, their behavior under pressure, molding powders into solid forms, dies, punches and presses, and a detailed discussion of hot pressing are then taken up, followed by four chapters on sintering, including principles and practices, furnaces, and neutral and reduced atmospheres. The book concludes with chapters on working and heat-treating after sintering and an exhaustive chapter on finishing treatments. Footnote references are included throughout, and author and subject indexes are provided. The author is Vice-President and Director of Research, Sintercast Corporation of America, and Adjunct Professor of Chemical Engineering at New York University.

Electrons, Atoms, Metals and Alloys. William Hume-Rothery. London, Published for "Metal Industry" by the Louis Cassier Co. Ltd., Distributed by Iliffe & Sons, Ltd., 1948. 377 pp., illus., diagrs. 25*s*.

Designed as an introduction into the more formal textbooks on the structure and properties of metals and alloys, the discussion in this book is in the form of a dialogue between an older metallurgist concerned with industrial problems and a younger scientist who has received his degree since the establishment of the Quantum Theory. The greater part of the dialogue consists of questions and observations by the older man and answers and amplifications by the younger. The author is a lecturer in Metallurgical Chemistry, University of Oxford, and Warren Research Fellow of the Royal Society.

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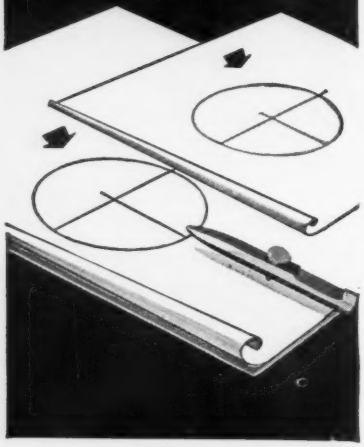

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Einführung in die Technische Röntgenphotographie (Introduction to Technical Röntgen Photography). John Eggert and Heinz Gajewski. (*Leipzig, S. Hirzel, 1942.*) Ann Arbor, Mich., J. W. Edwards, 1948. 224 pp., illus., diagrs. $8.00.

The authors point out that advances in technology in the last decade, especially in aircraft construction, have made necessary the most exact evaluations possible of materials in order to provide maximum strength with minimum weight. The first part of the book deals with the theory of Roentgen rays and particularly with the Roentgen photography process. The greater part of the book is concerned with practical applications, including apparatus, film, and paper; research on materials of coarse structure; research on materials of fine structure; Roentgen spectroscopy; protection of workers; and sources of error and their correction. Formulas for developing and fixing solutions and working tables of materials and equipment are included. The authors were associated with the photographic laboratory of I. G. Farbenindustrie A.G./Agfa.

Wood Adhesives. Edward H. Pinto. London, E. & F. N. Spon Ltd., 1948. 180 pp., illus. 12*s*. 6*d*.

This is a systematic review of types of wood adhesives, their selection, causes of failure, moisture resistance, and methods of application by use of pressure and heat. The theory of adhesives is discussed, and the properties of a great many adhesives are given. The appendixes include a summary chart of the properties of wood adhesives, a glossary, and a 4-page bibliography of standards, British and U.S. government publications, books, journals, and trade literature.

MODEL AIRPLANES

Model Jet Reaction Engines, with Notes on Suitable Models for Jet Engines. C. E. Bowden. London, Percival Marshall & Co., Ltd., 1948. 65 pp., illus., figs. 3*s*.

The greater part of this book is concerned with the principles of the ram-jet, turbojet, and pulse-jet engines. The application of jet engines to model aircraft is discussed throughout, with particular reference to the existing pulse-jet engines for models, the American Minijet and the Dynajet. Applications of jet engines to helicopters and such developments as the afterburner are included in the discussion.

PERSONAL FLYING

Aircraft Use in 1947. Washington, U.S. Civil Aeronautics Administration, Research Division and Office of Aviation Information, February, 1949. 62 pp.

Based on replies from about 10,000 aircraft owners to postcard questionnaires, this is the second annual report of its kind. In the United States as a whole, flying increased 67 per cent in 1947; the greatest increases being in far western states, especially in Arizona, California, Nevada, and Utah. About one-fourth of the total flying and of aircraft registrations is in C.A.A. region III, comprising eight North Central states.

POWER PLANTS

Thermodynamic Charts for Combustion Processes. H. C. Hottel, G. C. Williams, and C. N. Satterfield. New York, John Wiley & Sons, Inc., 1949. Part I, Text, 75 pp., diagrs., $2.60; Part 2, Charts, 23 pp., 8 folding charts, $2.40.

This work is intended to supply help in the determination of the best combination of fuel and power cycle for a given application by mapping thermodynamic characteristics to permit charting the course of any cycle using carbon, hydrogen, oxygen, and nitrogen in any proportions. As most combustion processes of interest involve the burning of moderately volatile hydrocarbons in air, these processes are treated rigorously in Chapters 2 and 3 on The Modified-Air Chart and The Burned-Mixture Charts. Chapter 2 covers low-temperature regions in which gas-law deviations may be important, and Chapter 3 covers high-temperature regions in which chemical dissociation may be important. Chapter 4 deals with the fourelement system less completely in respect to thermodynamic variables, emphasizing the compositions of systems which may be studied. The main text includes the smaller generalized thermodynamic charts in Chapter 4, and the larger charts, treating hydrocarbon fuels and air, are contained in Part 2, separately bound. The use of the various charts is illustrated in a number of examples, including the turbocompressor power plant; the compression-ignition (Diesel) cycle; the Otto cycle engine, unthrottled, throttled, and with supercharger, and in consideration of the effect of flame travel across the combustion chamber; ram-jet; turbocompressor engine with tailpipe burner; rocket, burning liquid monofuel; two-fluid rocket; and liquid-fueled rocket motor, operating between pressures other than 300 and 14.7 lbs. per sq.in. absolute. A bibliography of 72 items, with an author index is included in Part 1. Part 2 presents tables of some equilibrium gas compositions, eight tables of dimensionless functions of enthalphy, entropy, internal energy, and molecular weight at pressures of 300 and 14.7 lbs. per sq.in. absolute, the Modified-Air Chart, and the seven Burned-Mixture Charts.

Verbrennungsmotoren; Thermodynamische und versuchmässige Grundlagen unter besonderer Berüchsichtigung der Flugmortoren (Combustion Engines; Thermodynamic and Experimental Principles, with Special Reference to Aircraft Engines). Fritz A. F. Schmidt. (*Berlin, Julius Springer, 1939.*) Ann Arbor, Mich., J. W. Edwards, 1948. 326 pp., illus., diagrs. $9.00. (In German.)

This textbook was developed from Dr. Schmidt's lectures at the Technische Hochschule, Berlin, on the thermodynamics of supercharged engines, thermodynamics of aircraft engines and exhaust gas turbines, and advanced thermodynamics. The first part deals with the theoretical and experimental principles of the energy process in engines, particularly with the actual combustion process in Otto and Diesel engines, and problems

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of fuel-air mixtures, compression, ignition, and scavenging. Gear-driven superchargers and turbosupercharging are discussed in the last half of the book, including performance at altitude with and without supercharging and the relation of speed to engine performance. Various calculation methods, tables, and formulas are given in appendixes. A bibliography of more than 225 references, classified by subjects, is included.

Die Verbrennungskraftmaschine (The Internal-Combustion Engine). Edited by Hans List. Vol. 1—**Vorwort und Einführung zum Gesamwerk (Forward and Introduction to the Collected Work)**, by Hans List; **Die Betriebsstoffe für Verbrennungskraftmaschinen (Fuels for Internal-Combustion Engines)**, by A. von Philippovich; **Die Gaserzeuger (Gas Generators)**, by Kurt Schmidt. (Vienna, Julius Springer, 1939.) Ann Arbor, Mich., J. W. Edwards, 1948. 106 pp., illus., diagrs. $4.50. (In German.)

This is the first volume of a comprehensive work bringing together the results of recent research on internal combustion engines for aircraft, automobiles, and stationary power applications. Following the editor's introduction on the scope of the work, fuels and lubricants are taken up by Dr. A. von Philippovich, including a brief review of the phenomena of combustion, fluid fuels for Otto and Diesel engines, lubricants, and addition agents for fuels and lubricants. A bibliography of 69 items is included. Kurt Schmidt takes up gas producers, the fuels and processes involved in their operation, and their applications, with a brief discussion of cooling and purification of gases. A bibliography of 23 items is included.

Die Verbrennungskraftmaschine (The Internal-Combustion Engine). Edited by Hans List. Vol. 5—**Die Gasmaschine (Gas Engines)**, by Adolf Schnurle. (Vienna, Julius Springer, 1939) Ann Arbor, Mich., J. W. Edwards, 1948. 114 pp., illus., diagrs. $4.50. (In German.)

This volume is concerned with the design and performance of gas engines that use such fuels as natural gas, methane, propane, and butane and that are used principally for stationary power projects, trucks, and tractors. Fuels, combustion, and various researches on performance are dealt with in the first part. The second part includes the design and descriptions of the existing gas engines. Ignition devices and special questions of fuel injection and two-cycle design are covered in the two final sections.

PRODUCTION

Design for Welding in Mechanical Engineering. F. Koenigsberger. London and New York. Longmans, Green & Co., 1948. 210 pp., diagrs., illus., $4.50.

The author's purpose in this book is to coordinate theory and the results of research with actual design experience and experience in manufacture of welded structures. General design principles, materials, welded joints, the detail design of typical part assemblies, and typical structures are among the topics discussed. The final chapter deals with drafting practice in connection with welding design.

Engineering Materials and Processes. L. H. Hancock. London, Sir Isaac Pitman & Sons, Ltd., 1949. 214 pp., illus., diagrs. 15*s*.

Designed for the engineering student in the third year of the National Certificate Course in Mechanical Engineering, this textbook is divided into five sections. The section on materials (41 pages) includes pattern-making and molding. Cutting fluids and lubrication are included in the section on machine tools (79 pages). The section on processes requiring heat (36 pages) includes temperature measurement. Three chapters on testing of materials (20 pages) and one on jig and tool design (8 pages) conclude the book. A section of examination questions is included.

Aircraft Data Book. Los Angeles, Aero Industries Technical Institute, 1949. Loose-leaf, various paging. $2.50.

In the first part, this convenient book describes briefly such AN standard parts as bolts, pins, screws, nuts, locking devices, and turnbuckle assemblies, with alphabetical and numerical lists. Additional sections deal with blueprints and mathematics, sheet-metal layout, riveting, tubing and fitting, welding dope, and plexiglas. A number of useful tables are included.

PROPELLERS

Aerodynamics of the Propeller. F. Weinig. Translated and reproduced from the original German text. Dayton, Ohio, Wright-Patterson Air Force Base, Central Air Documents Office, Intelligence Department, Air Materiel Command, 1949. 501 pp., diagrs.

Dr. Weinig's original book was published in Berlin in 1940. This translation includes revisions and additions made by the author in 1947. The purpose of the author is to indicate points of view for selection of the leading dimensions of propellers and the variations required for a successful design. Possible variations in airplane design with regard to the propeller, considering the increasingly higher engine power, are also indicated. The bibliographies of the original work, containing over 400 references, are included.

REFERENCE LITERATURE

Sources of Business Information. Edwin T. Coman, Jr. New York, Prentice-Hall, Inc., 1949. 406 pp. $6.00.

The purpose of this volume is to provide the businessman, and others associated with business, with a guide to basic sources of information. Sources are selected, and critical notes and evaluations are provided throughout. The entire business field is covered, including statistical sources, financial information, real estate and insurance, accounting, management, marketing, sales management, advertising, industrial relations, basic industries, transportation, and foreign trade. The aviation specialist will be acquainted with the 30 or more sources listed for aviation but may not know all the more general sources indicated here which include aviation information. This guide is admirably organized and is well indexed. The author is Director of the Graduate School of Business Library at Stanford University.

SCIENCES, GENERAL

MATHEMATICS

Formulas and Theorems for the Special Functions of Mathematical Physics. Wilhelm Magnus and Fritz Oberhettinger. Translated from the German by John Wermer. New York, Chelsea Publishing Company, 1949. 172 pp. $3.50.

This is a translation of a book published in Berlin in 1943. The authors' purpose is to present mathematical techniques for use in mathematical physics, in readily accessible form, with particular reference to results expressible in formulas. The properties of a number of special functions are surveyed, including the gamma-function, hypergeometric function, cylindrical functions, spherical harmonics, orthogonal polynomials, the confluent hypergeometric function, theta-functions, elliptic functions and integrals, integral transformations and integral inversions, and coordinate transformations. A bibliography arranged by chapters is included.

MECHANICS—VIBRATION

Die Berechnung der Drehschwingungen, und ihre Anwendung im Maschinenbau (The Calculation of Torsional Vibrations, and Their Application in Machine Design). Heinrich Holzer. (*Berlin, Julius Springer, 1921.*) Ann Arbor, Mich., J. W. Edwards, 1948. 199 pp. diagrs. $4.50. (In German.)

The discussion of undamped vibrations includes simple vibrating systems and arbitrary multimass systems, free and forced vibration of an arbitrary mass system, torsional stress of a shaft through forced vibration, harmonic motion, elastic corollary systems, and coupled systems. The discussion of damped vibrations deals with damped vibration of a single-mass system, free and forced vibration of a multimass system with external damping, internal damping and mixed internal and external damping, in reference to free and forced vibration, and consideration of the shaft mass with internal and external damping. The emphasis throughout is upon calculation methods for the machine designer.

STRUCTURES

Aircraft Weight, Balance and Loading. Charles Edward Chapel. Los Angeles, Calif., Aero Publishers, Inc., 1948. 149 pp., illus., diagrs. $3.25.

The fundamental principles of weight and balance, weight distribution, and weight and loading are discussed in the first third of this book. Step-by-step procedures on how to weigh an airplane and how to locate the c.g. of an empty airplane are next considered, including a chapter on c.g. locations. The final chapters deal with problems involving alterations and ballast and charts and tables for the solution of loading problems for medium- and large-sized airplanes. An advanced loading problem is discussed step by step in the last chapter. The book is designed for students, pilots, flight engineers, aircraft owners, and aircraft mechanics. Excellent diagrams and illustrations accompany the text, and each chapter ends with a set of review questions.

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Student Branches

(*Continued from page 13*)

Syracuse University

On May 18, new officers were elected as follows: Honorary Chairman, Professor M. E. Barzelay; Chairman, Philip R. Woodford; Vice-Chairman, Frank Stearns; Secretary, Bruce Wills; Treasurer, Fred Beise.

Colombus Boison, Graduate Student in the Aeronautical Department, was awarded the Student Branch Scholastic Award.

University of Texas

The Power Show, held May 6, took the place of the regular May meeting. The Student Branch was awarded the Gold Cup for the best exhibits in the show. These included a V-2 rocket engine, which was run near the Engineering Building, and a miniature radial six-cylinder engine.

In the Aeronautical Laboratory, a water tunnel for showing flow over different surfaces and a wind tunnel for illustrating stall characteristics were on exhibit. Vibration models and an aerodynamic display also were set up.

University of Toledo

Election of officers for the fall semester of 1949 resulted in the following: Chairman, Mark A. Pawnall, Jr.; Vice-Chairman, John Kozak; Secretary-Treasurer, Marion Antonini.

The chief speaker, William D. Wenzlau, Instructor, College of Engineering, Toledo, presented a talk on "Shock Waves in Wind-Tunnel Design."

Tri-State College

At the May 25 meeting a report was given on the V-Tail Project by N. Sensenbaugh, who told the members the tail was being reworked and should be ready by fall.

A film, *Something to Shoot For*, and a United Air Lines release were shown.

Virginia Polytechnic Institute

A Membership Campaign Committee was appointed at the May 10 meeting for the purpose of encouraging freshmen and other nonmembers to attend meetings and become members of the Student Branch.

A film, *PBM-3 Wing Destruction Test*, was shown.

University of Washington

"Development and Test Flight of the XB-47" was the subject of a talk by Robert Robbins, Assistant Project Engineer, XB-47, Boeing Airplane Company.

Robbins opened with a comparison of the B-29 and the B-47 on the basis of engines, speed, and crew as a means of showing the present trend in bomber design.

Reduced noise and vibration in the B-47 are welcome changes in reducing pilot fatigue, Robbins said.

New officers elected at the May 16 meeting included: Arthur D. Reynolds, Chairman; William H. Blue, Vice-Chairman; Robert J. Brown, Secretary-Treasurer; James R. Osborn, Engineering Council Representative-at-Large; Harry R. Carroll, Junior Representative; Russell B. Light, Representative to Organizations Assembly; Richard H. Haase, Publicity Chairman; and Robert E. Gallagher, Senior Representative.

West Virginia University

Officers elected at the May 18 meeting were: Chairman, W. E. Lawson; Vice-Chairman, D. F. Thomas; Recording Secretary-Treasurer, V. G. Rockhold; Corresponding Secretary, J. C. Law.

University of Wyoming

"Some Problems of Modern High-Speed Flight" was the title of a talk given by Dr. Harold W. Sibert, Professor of Aeronautical Engineering, University of Colorado, at the May 13 meeting attended by 14 members and 30 nonmembers.

Dr. Sibert was introduced by Laurence R. Soderberg, Honorary Chairman and Faculty Adviser.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Chidlaw, Benjamin W., B.S., Lt. Gen., U.S.A.F.; Deputy Commanding General, A.M.C., Wright-Patterson Air Force Base.

Transferred to Associate Fellow Grade

Burr, Paul J., Cmdr., U.S.N.; Dir., Naval Air Experimental Station, Naval Air Material Center (Philadelphia).

Stinson, William Evans, Preliminary Design & Project Engineer, Bell Aircraft Corp.

Elected to MEMBER Grade

Adams, Harold E., B.S., Chief Engineer & Dir., The Nash Engineering Co.

Adler, Charles, Jr., Consulting Engineer Aircraft Lighting & Signaling.

Blauvelt, Robert, Special Problems Inspector, Republic Aviation Corp.

Davis, Harry O., Jr., B.S., Design Group Engineer, Lockheed Aircraft Corp.

Dunholter, Howard F., Ph.D., Chief of Thermodynamics Group, Consolidated Vultee Aircraft Corp.

Epstein, Albert, M. of Ae.E., Design Engineer, Technical Liaison, Republic Aviation Corp.

Foster, Mark Gardner, Ph.D., Asst. Head, Engineering Physics Dept., Cornell Aero. Lab., Inc.

Green, Frederick Hammond, B.A., Preliminary Design Engineer, AiResearch Mfg. Co.

Karnuth, Richard E., B.S. in Ae.E., Assoc. Research Engineer, Cornell Aero. Lab., Inc.

King, J. H., B.S. (Aero.), Project Engineer, Bell Aircraft Corp.

Rothrock, Lawrence Moore, B.S.M.E. (Aero.), Flight Test Engineer, Northrop Aircraft, Inc.

Scofield, Paul C., Project Engineer, AiResearch Mfg. Co.

Stuart, Milton C., M.E., Prof. & Acting Head, Dept. of Mech. Engineering, Lehigh University.

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Wulff, Roy A., Structures & Design Engineer, Electrol, Inc.

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23. Sales Engineer—Age 30–40. Aeronautical Engineering Degree. At least 5 years' sales experience on aeronautical instruments and familiar with thermocouples, electrical bridges, temperature sensing bulbs and indicators, fire detectors, relays, aircraft power supply, Ohm's law, and direct current. Neat appearance and progressive. Salary $5,000 to $6,000. Submit résumé for consideration.

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25. Contract Administrator—Administrative Engineer—Graduate engineer with 23 years' experience in the aviation industry covering aircraft and engine manufacturing and active duty during World War II in the Bureau of Aeronautics. Positions held have included responsible duties in engineering, financial, and administrative work, in most of which there was frequent contact with Government agencies, United States and foreign engineers, and technicians. Most recently, General Manager of a Research and Development contract coordinating opinions of authorities through aviation and allied sciences.

24. Power-Plant Engineer—M.E. and M.S., Stevens Tech. Licensed Professional Engineer. Fifteen years' experience in development of large air-cooled aircraft engines, including extensive staff and committee work, overseas experience, languages. Some lecturing and graduate-school teaching on aircraft power plants. East Coast resident.

19. Aviation Executive—Specialist with 16 years' aviation experience, domestic and abroad, air lines and manufacturers. Extensive background includes technical, operating, accounting, sales and publicity experience; many years in executive position with top consulting firm handling special research on air-lines' and manufacturers' problems. Good command of foreign languages; widely acquainted in aviation circles. Age 33; married; Southern California. Desires administrative position with air line or in aviation industry.

17. Aeronautical Engineer—B.S. Aero. E., Tri-State College, March, 1949, Graduate. Fifteen years in the aircraft field. Five years in the Air Corps as a technical inspector for all aircraft. Machine and Laboratory experience. Desires position in aircraft field in design, drafting, stress analysis, laboratory testing, selling, and maintenance. Age 35; married; available immediately.

16. Aeronautical Engineer—Pilot—B.S.A.E.; commercial pilot, single- and multi-engined land, instrument, and instructor ratings; Air Force Technical training in aircraft maintenance engineering. Seven years' experience, including aircraft maintenance, service, modification and flight-test engineering and passenger, ferry, instruction, and test piloting.

15. Manufacturing Executive—Desires position with East Coast Manufacturer. Twenty years' aircraft and allied manufacturing and engineering experience, both Europe and United States.

14. Aeronautical Engineer—Teacher—Ten years' experience teaching aerodynamics and allied subjects. Two years with Government agency as aerodynamicist. At present engaged in aerodynamic design of supersonic wind tunnels. Desires position that requires independent research and development on problems in supersonic, including wind-tunnel design. Location in South or West Coast preferred.

13. Development Engineer—B.S. in M.E., age 30, married. Ten years' progressive experience—aircraft power plants, fuel metering equipment, power controls, and accessories. Past 3 years, Assistant Project Engineer on turboprop and turbojet programs, including flight-test participation. Previous positions include Assistant Chief Inspector, Supervisor of Carburetor Test Laboratory, and Test Engineer. Desires engineering position involving experimental research or product development. Eastern States preferred.

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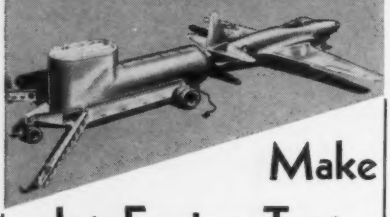

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11. European Professor of Aeronautical and Mechanical Engineering—Experience in airplane design in industry, in wind-tunnel work in research institute, and in teaching mechanics, aerodynamics, and airplane structures; would accept Assistant Professorship as first position in U.S. Spent 6 months at California Institute of Technology earlier on fellowship.

10. Research Associate—Ph.D. in Applied Mechanics, June, 1949, with 11 years' industrial experience in analysis, design, and production; 3 years' part-time teaching and analytical and experimental research in jet propulsion, compressible flow, and airplane structures. Desires Associate Professorship with research possibilities.

999. Public Relations Counsel—Wishes to handle public relations and representation work for aviation organization in Utica, N.Y., and vicinity. Many years' experience in civic affairs, publicity, and promotion. Former Rehabilitation Chairman of the N.Y. State Veterans of World War II. Aircraft overhaul experience in Navy, Air Force, and Coast Guard for 9 years. Fifteen years' experience in local public relations work.

998. Administrative Assistant or Aeronautical Engineer—Bachelor Aeronautical Engineering, Georgia Tech, 1946, and Master of Business Administration, Cornell University, 1949. Age 23; married. One year as research engineer with N.A.C.A., including tunnel operation and technical report writing. General administrative experience as Navy Ensign. Available immediately.

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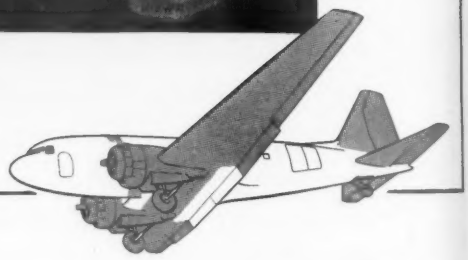

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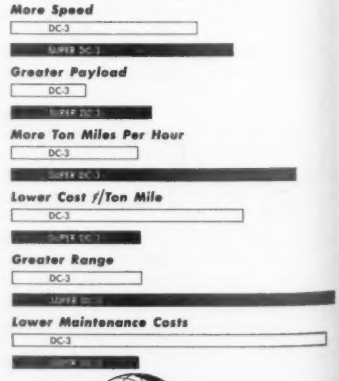

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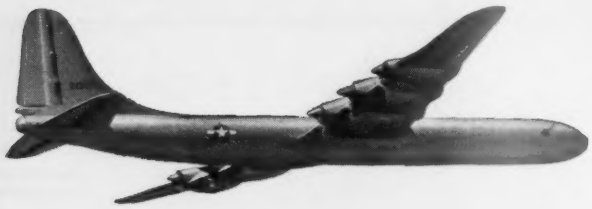

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